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AN ENHANCED PROCESS MODEL
OF THE INTRANSIT SEGMENT OF THE AIR FORCE
LOGISTICS REPARABLE PIPELINE

THESIS

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AFIT/GLM/LSM/93S-30

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AN ENHANCED PROCESS MODEL OF THE INTRANSIT SEGMENT
OF THE AIR FORCE LOGISTICS REPARABLE PIPELINE

THESIS

Presented to the Faculty of the Graduate School
of Logistics and Acquisition Management
of the Air Force Institute of Technology
Air Education and Training Command
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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Abstract

This thesis is an in-depth study of the intransit segment of the United States Air Force reparable pipeline. Previous research has not adequately discussed the role of the intransit segment in the overall pipeline. As a result, this thesis identifies the characteristics of this particular segment by discussing the following topics: various intransit components, reparable asset flow times, intransit's role under two-level maintenance, intransit constraints, and data sources used to manage asset movements within the pipeline. The study uses a thorough literature review, personal interviews, and an evaluation of asset flow time data to compare current standards to what actually exists in this particular pipeline segment. Applying Theory of Constraint principles, the constraints identified in the study's interviews, together with the research findings, are compiled to develop an effect-cause-effect diagram of the intransit system. The definitive thesis goal is accomplished by constructing an enhanced process model of the intransit pipeline segment.

AN ENHANCED PROCESS MODEL OF THE INTRANSIT SEGMENT OF THE
AIR FORCE LOGISTICS REPARABLE PIPELINE

I. The Problem

Introduction

The Air Force Logistics pipeline is a complex system which stores, repairs, and distributes reparable assets to Air Force units throughout the world. The Rand Corporation defines this system as "a network of repair and transportation channels through which repairable and serviceable parts (reparables) are removed from their higher assemblies, repaired, and requisitioned from other points of supply" (11:xv). In the Air Force, this network consists of an intricate group of activities whose goal is to have the right part, in the right place, at the right time. Over the past five years, numerous studies have been performed in order to develop a comprehensive model of the logistics pipeline in an attempt to determine deficiencies in pipeline processes. One area of the pipeline that has not been studied in detail is the segment which deals with the movement of unserviceable assets from the base to the depot for repair. This segment was previously identified in a 1991 AFIT thesis by Kettner and Wheatley as the intransit segment (13:54).

Problem Background

One of the first studies to conceptualize the pipeline was a 1989 Air Force Institute of Technology (AFIT) thesis

by Bond and Ruth entitled A Conceptual Model of the Air Force Logistics Pipeline. In their thesis, Bond and Ruth examined the functions of the logistics pipeline by identifying what they termed a "generic pipeline". They also described what they labeled the "Overall Air Force Logistics Pipeline" (Figure 1). The Air Force pipeline is composed of the following subsystems: 1) Base-level pipeline 2) Depot-level pipeline 3) Acquisition and 4) Disposal (2:3).

Using Bond and Ruth's conceptual pipeline model as a stepping stone, AFIT graduate students, Kettner and Wheatley, completed a 1991 study entitled A Conceptual Model and Analysis of the Depot Supply and Maintenance Pipeline for Reparable Assets. As a major part of their study, Kettner and Wheatley developed a model of the depot-level reparable pipeline (Figure 2). In their model, they identified these primary segments: 1) Base processing 2) Intransit 3) Supply to maintenance and 4) Serviceable turn-in (13:85).

The authors recommended that the four segments in their model be explored in greater detail. As a result, this study thoroughly investigates the various characteristics and components of the intransit segment, which begins when an unserviceable asset is delivered to the base transportation management office (TMO) and ends once that asset arrives at a depot repair facility (13:131). Within the intransit segment, the following subsegments were

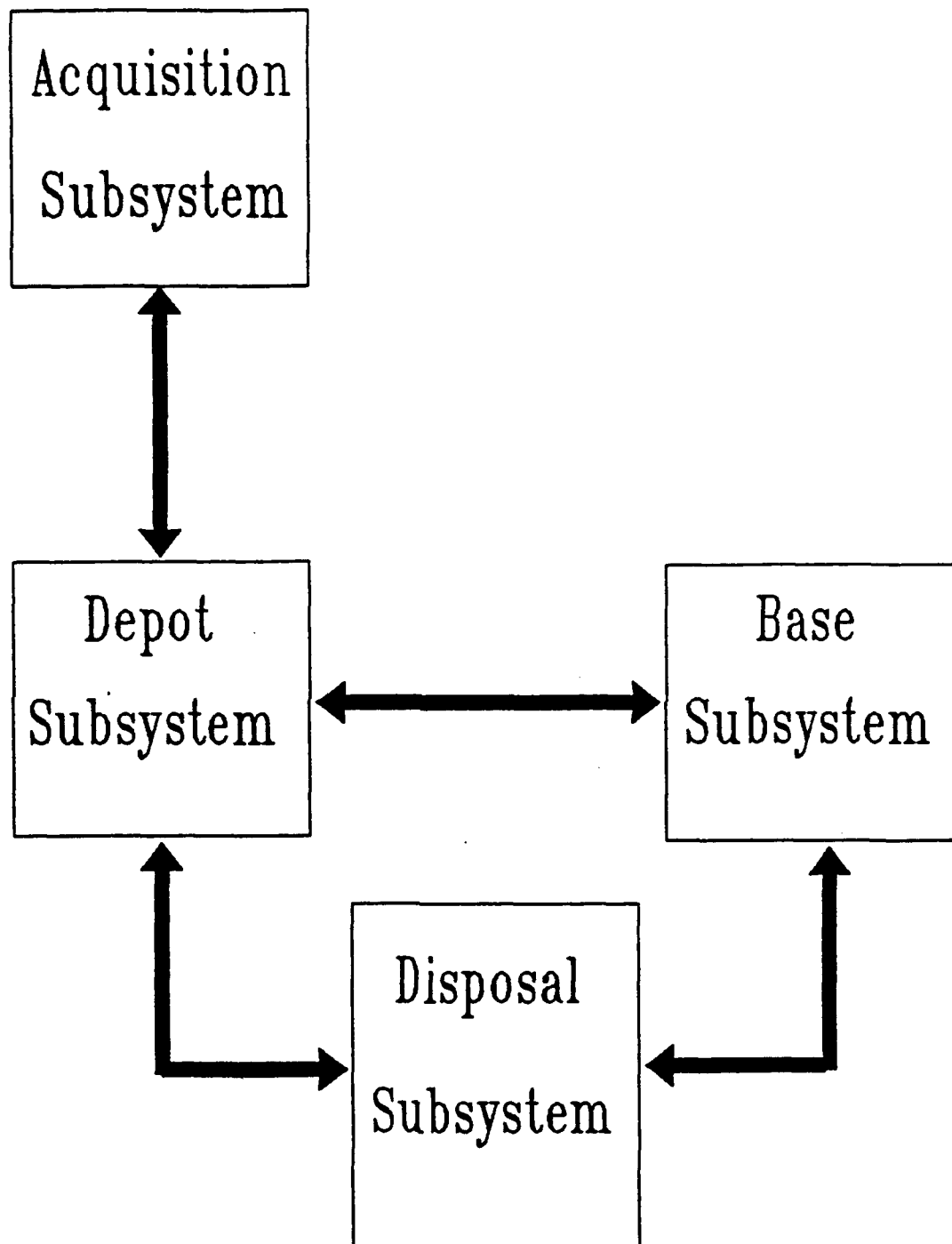


Figure 1. The Overall Logistics Pipeline
Adapted from: (13:3)

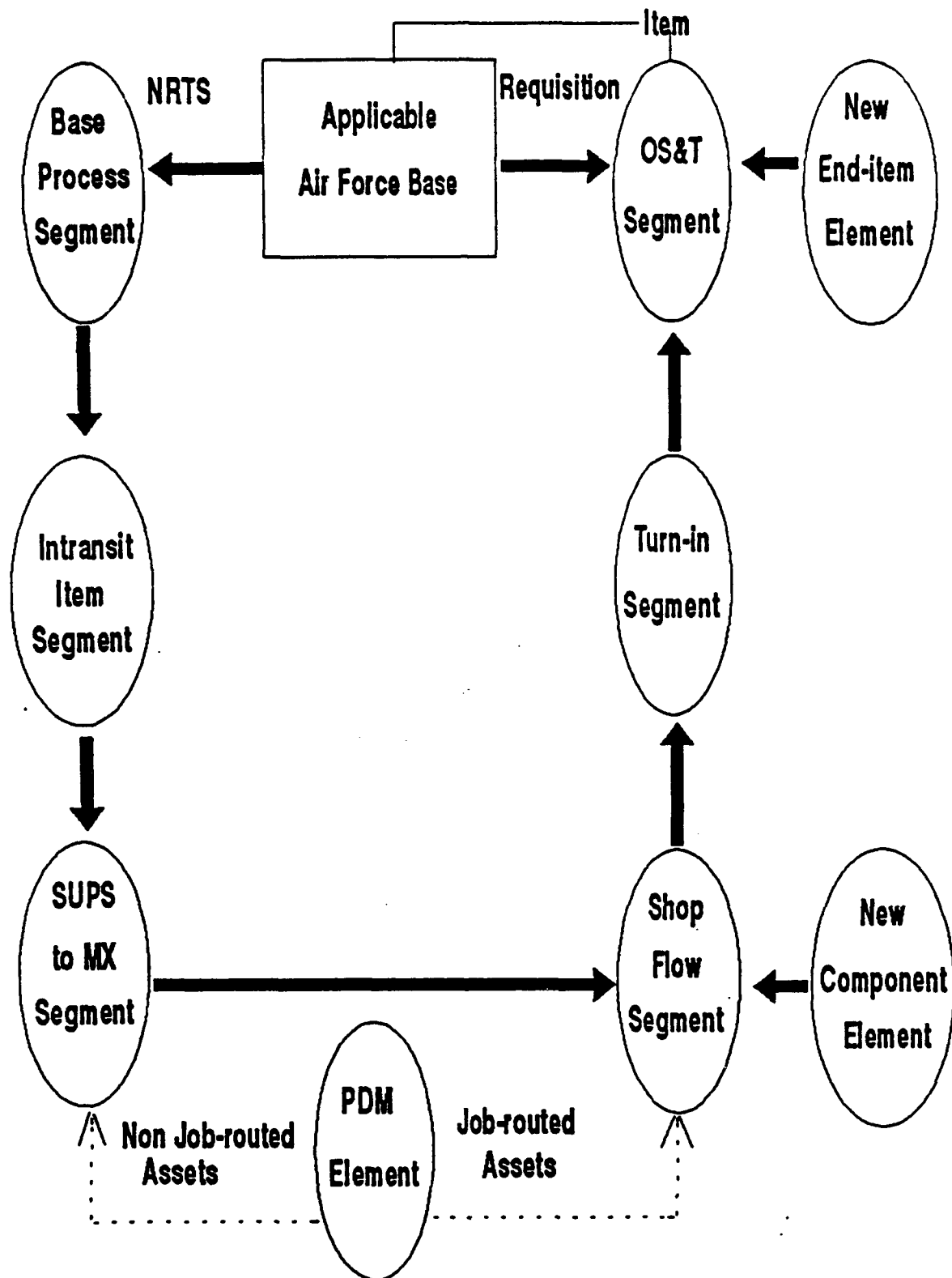


Figure 2. The Depot-Level Reparable Pipeline
Adapted from: (13:126)

identified: 1) Physical preparation 2) Carrier Scheduling
3) Cargo loading and 4) Unserviceable asset movement
(13:132).

General Issue

Over the past several years, the Department of Defense (DoD) budget has been reduced substantially. New budget restrictions require Air Force organizations to maintain effective operations despite decreased funding. One program that has been implemented to assist in achieving efficiency in logistics operations is the two-level maintenance (2LM) concept. This concept is a deviation from three-level maintenance (3LM), which is currently the primary maintenance philosophy. 3LM uses three levels of reparable asset repair: organizational, intermediate, and depot level. The first level of asset repair is organizational, which basically involves "repair and replace" maintenance. Under organizational maintenance, the unserviceable asset is removed from the aircraft, immediately repaired by flightline maintenance, and replaced on the aircraft.

The second level is "intermediate" maintenance. This maintenance is accomplished in base-level maintenance shops by specialized maintenance personnel (i.e., avionics personnel or hydraulics personnel). In the case of intermediate repair, assets are removed and replaced with another serviceable asset from base supply stock. Once removed, the unserviceable asset is sent to the intermediate shop and held until repair is completed. After repair, the

asset is sent to base supply serviceable stock or back to the aircraft if there is an immediate need.

The final level of repair under 3LM is depot repair. Depot repair occurs when there is a "Not Repairable This Station" (NRTS) asset. This happens in situations where the base is unable to accomplish the repair or does not have the maintenance capability for the repair. NRTS assets are sent through the various transportation channels and back to the depot for repair. After the depot repairs the asset, it is held in stock until there is a base demand for the asset.

The 2LM concept narrows the scope of base-level maintenance to repair and replace maintenance only. It attempts to remove intermediate base level repair by relocating this capability to various depot repair sites. In July 1991, the Air Force began initial testing of 2LM at Ogden Air Logistics Center, Hill Air Force Base (AFB), Utah. Unserviceable F-16 avionics assets from the 388th Tactical Fighter Wing at Hill AFB were used to monitor the feasibility of maintaining only flightline and depot-level repair capabilities. This new concept and its resulting changes in base-level repair capacity will make transportation of reparable assets between bases and repair depots critical (15:2-1).

Specific Problem

The intransit segment is an important part of the logistics pipeline. While other segments of the logistics pipeline have been researched and identified, no detailed

model of the intransit pipeline currently exists. This segment is the portion of the pipeline which is responsible for ensuring NRTS assets are properly and promptly returned to the depots for repair. As a result of this responsibility, the intransit segment is a major factor supporting the 2LM concept. This thesis identifies the physical characteristics of the intransit segment. These characteristics include the segment's various components and its associated flow time processes. The study creates a conceptual model of the intransit segment by answering the following research question:

Research Question

Are the characteristics and components of the intransit segment of the reparable pipeline properly identified and measured?

Investigative Questions

1. What is currently accepted as the Air Force standard of the intransit segment of the pipeline?
2. Do the standards of the components within the intransit pipeline segment represent legitimate reparable asset flow times?
3. Do the measurements used by Air Force managers properly monitor the components of the intransit segment?

Scope

The Air Force logistics pipeline is a large, complex system which contains hundreds of millions of dollars in

consumable and reparable assets at any given time. This thesis is a study of the intransit segment as it relates to the reparable pipeline. To remain within the scope of the thesis, the research will be limited to the following issues:

1. Because the logistics pipeline's characteristics are considerably different during wartime, this study assumes a peacetime environment.
2. This study focuses on the intransit segment of the pipeline and does not evaluate other pipeline segments.
3. This study views the intransit pipeline as a one-directional flow from base transportation to depot central receiving.
4. The study does not consider bases outside the continental United States.

Chapter Summary

This chapter provided a background of the Air Force logistics pipeline and described how the two-level maintenance concept will intensify the importance of the intransit segment. It discussed how Department of Defense budget reductions will intensify the need for quick asset turnarounds and minimal time in transportation channels. The intransit segment was noted as a crucial element of the Air Force logistics pipeline and a major supporter of the two-level maintenance concept. Finally, the chapter

concluded with the study's research question and
investigative questions and a discussion of the scope of the
thesis.

II. Literature Review

Introduction

This chapter is a review of existing literature pertaining to the intransit segment of the Air Force logistics pipeline. Its purpose is to better define the characteristics of this particular segment of the overall pipeline, which consists of a network of systems and subsystems through which reparable or Not Repairable This Station (NRTS) assets flow in support of Air Force missions.

Although past studies mention the importance of the intransit segment, no previous research provides details concerning this particular section of the pipeline. One major deficiency in the current body of literature is the lack of material addressing the movement of NRTS assets to the depot. Using available sources, this literature review thoroughly identifies aspects of the intransit segment and assists in answering the following investigative questions:

1. What is accepted as the Air Force standard of the intransit segment of the pipeline?
2. Do the standards of the components within the intransit pipeline segment represent legitimate reparable asset flow times?
3. Do the measurements used by Air Force managers properly monitor the components of the intransit segment?

The chapter begins with an examination of previous pipeline studies and discusses the components and characteristics of the intransit segment. Following this discussion, the role of the intransit segment under the two-level maintenance program is addressed. Finally, an overview on the application of effect-cause-effect (ECE) diagrams to the intransit pipeline is presented.

Previous Studies

In 1989 as part of an Air Force Institute of Technology (AFIT) thesis, Bond and Ruth developed the first conceptual model of the USAF logistics pipeline (2:33). Dividing the pipeline into four major subsystems, Bond and Ruth identified the transportation segment as an important connection between each of these subsystems. The authors state that at any one time a "substantial portion of the total assets in the pipeline are within the transportation system linking the five Air Logistics Centers and Air Force users throughout the world" (2:68).

In 1991, AFIT students Kettner and Wheatley drew on Bond and Ruth's conceptual model to analyze the pipeline's depot-level reparable section. They identified the following four primary segments: 1) Base Processing 2) Intransit 3) Supply to maintenance and 4) Serviceable turn-in (13:48). The authors recommended further research be performed on each segment of their conceptual model in order to define all functions of the pipeline. As stated earlier, this study focuses on the intransit segment of the pipeline.

Intransit Segment

The intransit segment begins when an unserviceable asset is delivered to the base transportation management office (TMO) and ends once that part arrives at the depot (13:54). The segment consists of the following components:

1) Physical preparation 2) Carrier scheduling 3) Cargo loading and 4) Unserviceable asset movement (Figure 3).

With the exception of asset movement, these processes all occur at base level under two primary sections within (TMO)—Packing and Crating and Surface Freight (Figure 4). A functional outline and a complete description of the intransit pipeline segment are described below.

Physical Preparation. The first section of the intransit segment involves the physical preparation of reparable assets. This activity begins when base supply delivers a Not Repairable This Station (NRTS) asset, along with the Issue/Receipt Document, DD Form 1348-1, to the Packing and Crating section of the TMO. Upon receipt of the NRTS asset, a transportation representative ensures the DD Form 1348-1 and item are correctly matched. After inspection, pertinent shipment data is entered onto the paperwork, which is then signed and dated on the number one or control copy of the shipping document (5:47).

Pertinent information regarding the package weight and contents is entered into blocks 13 and 18 of the DD Form 1348-1. Next, important shipping information from the DD Form 1348-1, such as document number and transportation

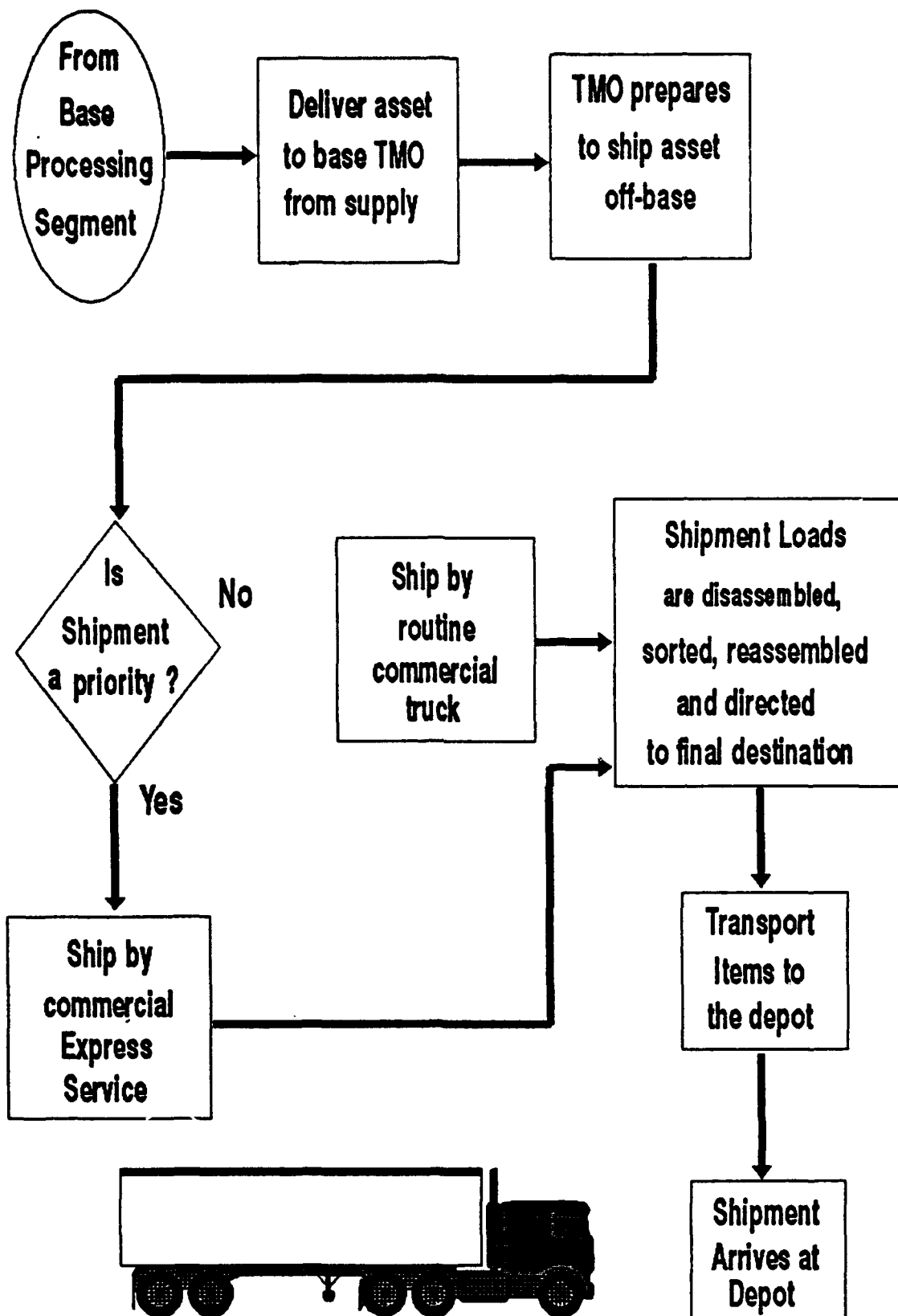


Figure 3. The Basic Intransit Pipeline Segment
Adapted from: (13:131)

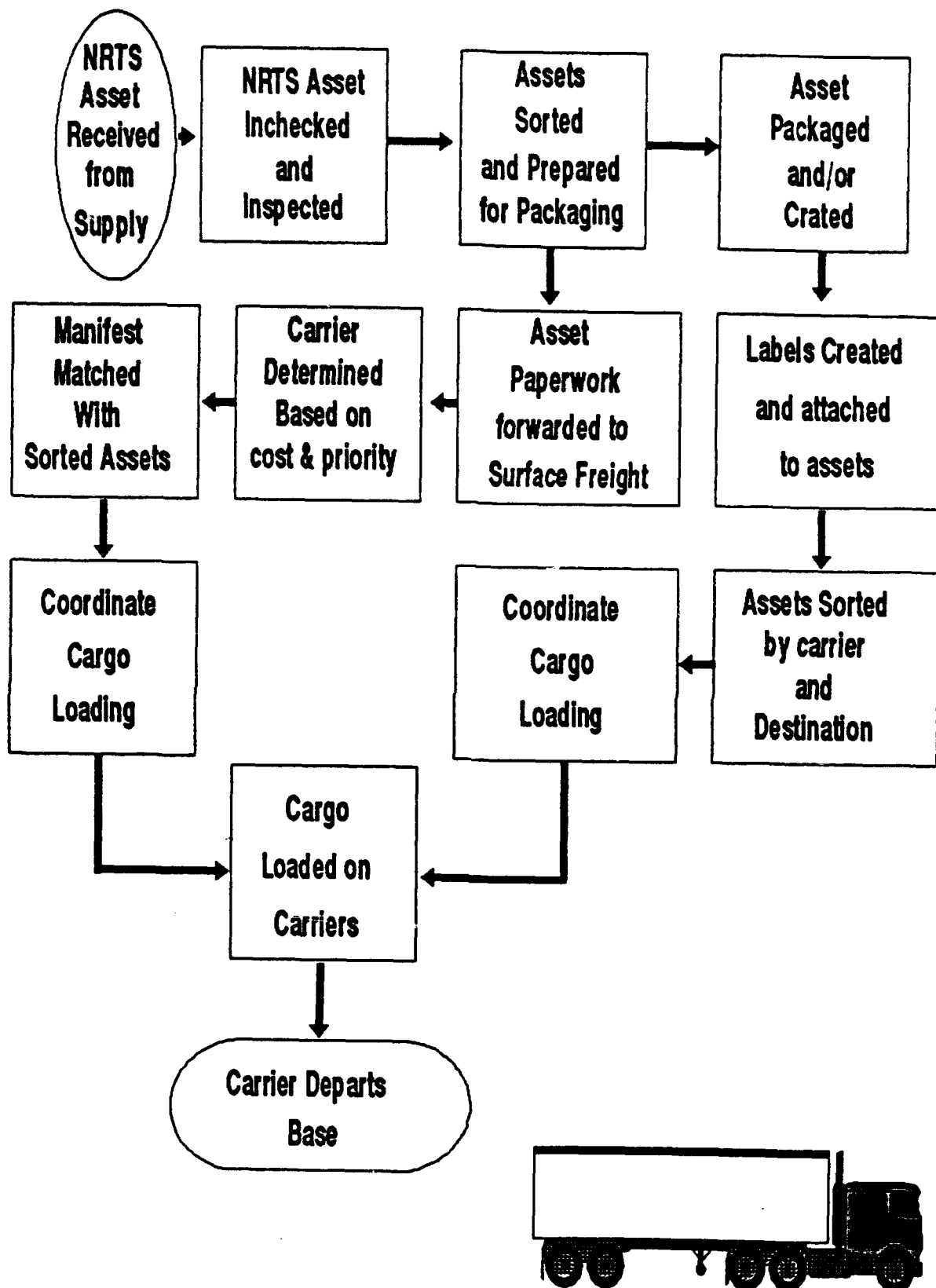


Figure 4. Packing and Crating & Surface Freight Sections

control number (TCN) are entered into computer terminals in order to produce appropriate shipping labels (5:52). The TCN serves as a tracking mechanism for assets going through transportation channels. Once produced, these labels are attached to the physically prepared assets and the 1348-1 is forwarded to the Surface Freight section for selection and scheduling of a transportation carrier.

Carrier Scheduling. Determining transportation priority and mode of transportation (motor carrier, postal, air carrier, and so forth) is the responsibility of the Surface Freight section. In making this selection, planners consider the following elements: urgency of need, cost, pipeline time standards, and carrier performance. Without exception, the optimum choice relating to carrier selection requires making tradeoff decisions with respect to the various elements (20:11). According to AFR 75-1, the two primary forms that TMO considers in choosing transportation modes are surface carriers and air carriers.

a. **Surface Carriers:**

(1) *Railroads.* Railroads have great flexibility and offer carload, less-carload, and terminal services.

(2) *Motor Trucks.* Motor truck services generally range from general commodity haulers to specialized carriers.

(3) *Bus Package Express Service.* Shipments are handled terminal to terminal with pickup and delivery service available at extra cost.

(4) *Water Transportation.* Water transportation is especially suited for moving large quantities of bulk or container traffic. Both common and contract carriers can be used.

(5) *Freight Forwarder*. The freight forwarder generally handles shipments and consolidates them into carload or truckload lots which are then moved via common carriers.

(6) *Postal*. The US mail service is an excellent alternative means of shipping small parcels.

(7) *Parcel Service*. Parcel service expeditiously moves small shipments at a competitive cost. Shipments are accepted for movement between points in areas where a specific carrier provides service.

b. Air Carriers and Services:

Air carriers offer a variety of express and cargo services that have the advantage of speed and flexibility. The various types of air service are:

(1) *Small Package*. Small package air carriers offer air transportation of small packages and documents. Some carriers offer air transportation for hazardous materials.

(2) *Air Freight Forwarder*. The air freight forwarder specializes in consolidating, shipping, and distributing small-lot shipments.

(3) *Defense Transportation System*. Air Mobility Command is used to move large packages or shipments (5:9-10).

Ultimately, TMO chooses shipping methods that deliver items at the lowest overall cost to the government. "Lowest overall costs" include expenses such as preparation for shipping, unpacking, reassembling, etc., which may vary with different transportation modes (5:8). Regardless of the form selected, TMO ensures maximum consolidation of assets within the limits established by transportation priorities (5:10).

Cargo Loading. Once a carrier is selected, cargo is loaded onto appropriate vehicles as they become available. This specific activity is a major concern for pipeline

managers. For optimal delivery and resupply of spares, the cargo loading function must adequately respond to workload surges in order to operate effectively (23:31). Assets are carefully checked against the manifest to ensure TCNs match the loaded property. After the manifest is signed, base transportation relinquishes property responsibility.

Some potential concerns within the cargo loading activity are a lack of forklifts, truck docks, pallet pits, and a shortage of personnel. These situations can severely hamper the streamlining of assets through the pipeline (2:80). If planners ignore the importance an efficiently run surface freight section plays in the flow of cargo, resupply of reparable spares may likely fall below desired standards. Bond and Ruth state that the cargo loading activity can be the biggest cause of constraints in the flow of assets through the system because of facility capacity and internal operations (2:80).

Unserviceable Asset Movement. Asset movement begins when the carrier picks up property and ends once the shipment is delivered to the depot. The transporting of assets adds place utility to the pipeline by moving material across long distances and simultaneously creates time utility by determining how fast an item arrives at its destination (22:172). For a profit-oriented company, the consequences of not having a product available could lead to dissatisfied customers, lost sales, or downtime (22:173).

Although these concepts are primarily applicable to the private sector, they can also be applied to U.S. Air Force operations. For example, the slow movement of critical aircraft spares through the pipeline can result in system "downtime" and can certainly "dissatisfy" base customers. With the continued downsizing of the Air Force and especially with the implementation of two-level maintenance (discussed later), the transportation of reparable items will need to be as efficient as possible.

Intransit Improvement Efforts. Now that more stringent fiscal constraints have been imposed, Air Force inventory managers are striving to maintain the same high levels of readiness while faced with leaner inventory investment funding (19:5). Every effort must be made to improve the pipeline process, thus reducing inventory levels, improving customer service, and reducing the flowtime of inventory through the pipeline (20:1).

Within the intransit segment, one effort to improve the pipeline process has been the development of the Cargo Movement Operations System (CMOS). CMOS's goal is to provide automated logistics support to base-level transportation activities (1:2). To accomplish this goal, CMOS automates the receipt, processing, and movement of material within the transportation system. Processing and passing this information in an accurate and timely manner, "CMOS allows transporters to effectively plan and schedule shipments into the transportation pipeline" (1:2).

Transportation Priorities

The length of time assets actually spend in the intransit segment is primarily determined by transportation modes selected and priorities assigned. Air Force Regulation 75-1 directs that transportation priority (TP) be based explicitly on the supply priority listed on the DD Form 1348-1 shipping document (Table 1). Supply priorities 01-03 become TP1, 04-06 translate into TP2, while 07-13 convert to TP3. The time allotted for processing TP1 assets is two days, TP2 three days, and TP3 eight days (5:76). These priorities are major factors in selecting the correct mode of shipment .

Assets which fall in the TP3 category are usually shipped via commercial surface carriers that are approved by the Military Traffic Management Command (MTMC), which has responsibility for managing surface freight activities within the Department of Defense. MTMC sends a list of carriers to each base, where selections are then made based on dependability and cost of the carriers (5:7). Selected companies are notified by Surface Freight when assets require shipment. Because of the less urgent nature of TP3 assets, they can be held for up to 8 days. As a result, shipments are often consolidated according to destination, thus requiring fewer carriers. This method is the most economical mode of transportation. However, items must be monitored by Packing and Crating personnel to ensure the time criteria is met (5:7).

TMO planners must also ensure shipments adhere to the standards established by the Uniform Material Movement and Issue System (UMMIPS). UMMIPS establishes a priority system between depots and base-level organizations using a series of numeric codes, called priority designators, to emphasize the importance of requisitions and other transactions affecting the movement of materiel (3:24-3). This emphasis, however, does not apply to NRTS assets. Current literature extensively discusses the "pulling" of serviceable assets from the depots, but hardly mentions the "pushing" of NRTS assets to the depots. A brief description of the UMMIPS system is provided below.

UMMIPS. UMMIPS uses two basic input codes for assigning priorities: the Force/Activity Designator (FAD) and the Urgency of Need Designator (UND). The FAD, a Roman numeral I through V, is established by the Secretary of Defense, the Joint Chief of Staff, or by each branch of service to indicate the mission essentiality of a unit (6:1). The UND, an alphabetical letter, is determined by the using activity. Through the combination of the assigned FAD and the UND, the user can determine the appropriate priority designator (Table 2).

NRTS assets are moved without regard to the FAD of units involved. The main determinant of the priority designator depends "on the importance of the materiel in the overall distribution system, as determined by the materiel manager" (6:8). At base level, the materiel manager is

TABLE 1: TRANSPORTATION PRIORITIES AND RECOMMENDED
SHIPMENT MODES ADAPTED FROM: AFR 75-1 (5:76).

Supply Priority	Trans. Priority (TP)	Materiel Work Schedules and Processing Time Measurements	Release to Consignor	Approved Shipment Modes
01-03	TP 1	24-hour day 7-day week	Within 24 hours after recording begins	Highspeed or most efficient means available
04-08	TP 2	Priority designator (PD) 04-08 MICAP are processed as PD 01-03. All others are processed as a minimum during the week. Time begins on the hour of receipt	Within 72 hours after recording begins	(Air)
09-15	TP 3	Regular shift workday. Normal five day workweek Time begins at the start of business on the next day of requisition.	Within 8 calendar days after recording begins	Same as above when RDD is less than required for SDD; otherwise SDD will determine mode (Surface)

TP = TRANSPORTATION PRIORITY
RDD = REQUIRED DELIVERY DATE
MICAP = MISSION CAPABLE
SDD = STANDARD DELIVERY DATE

**TABLE 2: UNIFORM MATERIEL AND ISSUE
PRIORITY SYSTEM (UMMIPS)**

FORCE ACTIVITY DESIGNATORS (FAD) CODES

I	II	III	IV	V
COMBAT	COMBAT READINESS	DEPLOY READINESS	ACTIVE & RESERVE	OTHER

URGENCY OF NEED (UND) DESIGNATORS

A	B	C
CANNOT PERFORM MISSION	MISSION CAPABILITY IMPAIRED	FIRM FUTURE RQMT & STOCK REPLENISHMENT

UND

FAD	(A)	(B)	(C)
I	1	4	11
II	2	5	12
III	3	6	13
IV	7	9	14
V	8	10	15

PRIORITY

Source: AFM 67-1, *Basic Air Force Supply Procedures*, vol.2, pt.2, chap.9, atch. C-4 "Uniform Materiel and Issue Priority System (UMMIPS)", 1 July 1992, p. 9-111.

normally the Deputy Commander for Logistics or the Chief of Supply. At the depot, the materiel manager is usually the Item Manager. Priority designators 03, 06 and 13 are prescribed for NRTS assets as follows:

a. Priority Designator 03 is used for returning critical items and approved intensive management items.

b. Priority Designator 06 is used for automatically returning materiel identified by the materiel manager.

c. Priority Designator 13 is used for routinely returning materiel not covered above (6:9).

Intransit Flow Time Standards

The Air Force Materiel Command's Recoverable Consumption Item Requirements System (D041) computes flow time standards for all Air Force reparable (4:1). The D041 obtains the information for these computations from four sources--actual, computed, estimated, or standard data and derives the computations based on the time assets spend in various pipeline segments (21:18). Actual data is "received through an interface with a mechanized data system."

Computed values are "mechanically computed or assigned by the D041 system" and item managers assign estimated values (4:44). As a default value for any asset, Headquarters Air Force Materiel Command (AFMC) develops standard flow times for each pipeline segment based on historical records. According to the D041, the current reparable intransit standard is set at 16 days (21:18).

In order to validate this standard, the Air Force Logistics Management Center (AFLMC), Gunter Air Force Station, averaged receipt times at all five Air Logistics Centers. They computed average reparable intransit time to be 14.4 days compared to the current D041 standard of 16 days (21:19). According to the AFLMC study, if the overall pipeline time could be reduced by one day, this small reduction could save as much as \$25 million in procurement costs alone (21:19).

Intransit Measurements

In order to effectively control reparable in the logistics pipeline, managers need accurate data to monitor the performance of all elements within the pipeline. Ploos van Amstel states that pipeline control comprises the sum of all activities that are designed to ensure that the flow of goods moves as efficiently as possible (20:11). Based on personal interviews with transportation experts and technicians in the field, it is apparent that not much attention is given to managing asset movements using standardized reports. AFR 75-1 mandates that inventory of all on-hand cargo must be completed a minimum of 3 times per week to ensure asset movement (5:47).

Role Under Two-Level Maintenance

In July 1991, the Air Force began initial testing of the two-level maintenance (2LM) concept, which consists of only flightline and depot-level repair. 2LM is a deviation from the primary three-level maintenance (3LM) system used

by the Air Force. 3LM consists of the following levels of reparable asset repair: 1) Organizational-- An unserviceable asset is removed from an aircraft, immediately repaired by flightline troops, and placed back on the aircraft 2) Intermediate-- Repair performed by base-level maintenance squadrons. After work is completed, the repaired asset is sent to base supply stocks or directly back to the aircraft, and 3) Depot-level repair -- Occurs when base maintainers cannot accomplish repairs (12:8). Reparables are shipped to the depot by various modes of transportation.

As a result of implementing 2LM, the intermediate base level repairs have significantly been reduced and are now performed at several depot facilities. According to Major General Richard D. Smith, former Deputy Chief of Staff for Logistics, Headquarters AFMC, 2LM is expected to provide the Air Force with substantial savings (12:7). The General states, "It's primarily cheaper because the civilian labor (at the depot) is less expensive than military labor, and less equipment is needed such as that in avionics intermediate shops" (12:6). 2LM will eventually eliminate the need for some base-level repair of aircraft parts and equipment and will affect the entire Air Force (12:8). Its aim is to improve the current system, which involves a costly intermediate level that requires significant airlift to support a deploying base-level maintenance squadron (12:8).

Along with a reduction in intermediate base-level repair capacity, there will also be a spares shortfall at base-level. Under three-level maintenance, more than 70 percent of reparable assets were repaired at base maintenance shops. As a result, the need to stockpile spare parts was minimal. However, with much of the repair workload now going to the depots under 2LM, the reparable need to travel through the pipeline quickly to keep weapon systems combat ready and spares at a minimum (12:9).

Two-level maintenance places added emphasis on reparable asset management and intensifies the importance of minimal flow time standards for all segments of the pipeline. Because of the importance of intransit times under a 2LM system, logistics planners need to ensure the pipeline is capable of providing a smooth and reliable flow of inventory. Pipeline flow time reductions will be essential to the effectiveness of the two-level maintenance concept (15:2-1).

Since July 1, 1992, unserviceable F-16 avionics components from the 388th Fighter Wing at Hill AFB and nine other operational units have been sent directly to Ogden Air Logistics Center for repairs under a program known as CORONET DEUCE (12:8). By focusing on the needs of their customers, CORONET DEUCE team members reduced average depot repair turnaround time from almost 22 days to approximately one day. CORONET DEUCE process improvements have resulted in a substantial decrease in a reparable's overall time in

the pipeline (for continental U.S.) to six days versus about 70 days before the improvements were implemented (12:8).

In CORONET DEUCE II, Ogden Air Logistics Center personnel studied the difference in transportation cost of line-replaceable units/shop-replaceable units (LRUs/SRUs) under the two different concepts of maintenance (13:26). Using RAND Corporation's Dyna-METRIC 6 Model, NRTS (not repairable this station) quantities for LRUs/SRUs were generated for both three-level and two-level maintenance scenarios (11:26). Based on their conclusions, CORONET DEUCE team members recommended that transportation times be reduced by routing military transport or commercially contracted aircraft directly to participating two-level bases (15:26).

In addition, they mentioned assigning codes to expedite processing, determine intransit status, and capture critically important transportation data for managing asset movements through the pipeline. Team members also stated that by mechanizing transportation receipt procedures assets can flow quicker through the pipeline (15:27).

Effect-Cause-Effect Diagrams

A potential tool for reducing pipeline flow time is the effect-cause-effect (ECE) diagram employed by the Theory of Constraints (TOC) philosophy. TOC is a management philosophy in which every action, improvement, decision, or policy is measured in terms of its effect on the overall goal of an organization (8:4). Concerning the pipeline, TOC

would call attention to streamlining the processes within the intransit segment by focusing on reducing the time required to process units through critical operations, which may be constraints in the organization (19:6). Dr. Elihayu Goldratt, who developed TOC in the 1980s, defines a constraint as: "anything that limits a system from achieving higher performance versus its goal" (8:4). According to Dr. Goldratt, the initial step in improving any system is to accurately define the overall purpose, or goal, of the organization (8:4).

Additionally, the measurements that enable managers to judge the impact of a particular subsystem or local decision must be determined. Consequently, once the organizational goal and measurements are identified, the process of improvements can begin. One of the most powerful tools used in TOC to pinpoint core problems and speculate plausible causes is the ECE method. ECE is a process of "speculating a cause for a given effect and then predicting another effect stemming from the same cause" (8:32). The ECE develops a logical "tree" or diagram of an entire process and uses explanations and logical derivations to explain a system process. The causes in an ECE diagram are called undesirable effects (UDEs) and are actually the symptoms of the core problems.

These diagrams serve as a "common sense" approach of showing that constraints have been identified. These constraints, which are analogous to the roots of a tree,

represent the primary causes of poor system performance. Diagrams are very effective in describing a system's physical operation and "serve as benchmarks for how a system is actually functioning, not how someone assumes it is operating" (21:6). ECE diagrams not only group the causes of a particular problem under several related categories, but also group related causes together and depict the relationship among them.

Chapter Summary

This chapter reviewed previous pipeline research in relation to the intransit segment in order to obtain a better understanding of the various components of this particular section of the pipeline. A detailed description was provided for the following four subsystems of the intransit segment: 1) Physical preparation 2) Scheduling of carriers 3) Cargo loading and 4) Actual asset movement.

In addition, current literature was presented which described typical intransit flow time standards for reparable assets. The reparable intransit time was defined as the moment an item is delivered to base transportation until the time the asset arrives at the depot. If the current standard was reduced by one day, savings of as much as \$25 million could be realized (21:19). As a potential process for reducing intransit time, a brief explanation of ECE diagrams was provided.

Although important, data and information used for managing asset movements is not given much attention in

current literature. Finally, the importance of the intransit segment's role under the two-level maintenance concept was discussed. Specifically, results from the CORONET DEUCE study were presented which indicate the need for expediting assets through the pipeline.

III. Methodology

Overview

This chapter defines the methods and procedures of research which were used to answer the study's basic research question. This methodology begins by restating the study's research and investigative questions. The chapter then presents a framework of the data collection methods and discusses how they are used in each investigative question. Next, the population of interest is thoroughly defined and the specific methods used to answer each of the three investigative questions are detailed. The chapter concludes with a discussion of the thesis's construction of an intransit Effect-Cause-Effect diagram using Theory of Constraint principles.

Research Question

The research question which is the focus of this study is:

Are the characteristics and components of the intransit segment of the reparable pipeline properly identified and measured?

Investigative Questions

The research objective of this thesis will be achieved by answering the following three investigative questions:

1. What is currently accepted as the standard Air Force description of the intransit segment of the pipeline?
2. Do the standards of the components within the intransit pipeline segment represent legitimate reparable asset flow times?

3. Do the metrics used by Air Force managers properly measure the components of the intransit segment?

Data Collection Methods

The following table is a framework of this thesis's data collection methods:

TABLE 3: DATA COLLECTION FRAMEWORK		
Investigative Question		Collection Method
1. What is currently accepted as the standard Air Force description of the intransit segment of the pipeline?	--	Literature Review
	--	Interviews/observation
2. Do the standards of the components within the intransit segment represent legitimate retrograde asset flow times?	--	Literature Review
	--	Retrograde Data Collection
3. Do the metrics used by Air Force managers properly measure the components of the intransit segment?	--	Literature Review
	--	Interviews
	--	Results from IQ#1 and IQ#2

This thesis utilized the framework in the following three ways:

Literature Review. As is evident from the table, a significant portion of this study's methodology involved a thorough literature review. This literature provides the background necessary to determine the current Air Force standard of the intransit pipeline. Literature sources included published articles, theses, and DoD directives.

Observations & Interviews. The second data collection method utilized observations and interviews. Observations were conducted at Wright-Patterson Air Force Base and Moody Air Force Base transportation squadrons. The on-site visit

at Wright-Patterson AFB was used as a pilot study and played a role in familiarizing the authors with the basic functions of a base-level intransit system. A second on-site observation was conducted at Moody AFB. The results of these observations provided the authors with a concrete physical description of a day-to-day intransit operation. This description assisted in validating the final conceptual model by identifying unique system attributes which were undetected in the literature review.

In addition to the on-site observations, interviews were also conducted at Wright-Patterson, Moody, and Little Rock AFBs. As was the case in the observations, the interviews at Wright-Patterson were used as a pilot study. In order to acquire relevant information and to encourage the free discussion of issues involving the nature of the intransit segment, the interview instrument consisted of open-ended questions. Emory and Cooper state, "open response questions are appropriate when the interviewer seeks sources of information, or when probes are needed to secure more information" (7:366).

An initial draft of the survey instrument was used in the Wright-Patterson test study. Following this trial application, the authors assessed the original questionnaire to ensure its applicability for exploring the intransit pipeline segment. After the initial instrument application and its subsequent evaluation, the authors were confident of the efficacy of their interview instrument. Once the

instrument was refined, telephone interviews were conducted with transportation personnel at Little Rock AFB and an on-site interview was conducted at Moody Air Force Base. The finalized interview instrument is included in Appendix B.

NRTS Data Collection. The third method of data collection came from the NRTS flow time data gathered from the sample of 120 reparable assets (Appendix C). This data represents one-directional base to depot NRTS flow times and was obtained from the Air Force Logistics Information File (AFLIF) database at Headquarters Air Force Materiel Command (AFMC), Wright-Patterson AFB.

The AFLIF system contains transportation information and transaction histories on all reparable assets within the Air Force inventory. These histories have been collected on all reparables from January 1991 to the present. The database was constructed to assist the USAF in maintaining transit asset visibility during Desert Shield/Desert Storm. The system remains intact and continues to report transportation information on Air Force assets as they move through the transportation channels of the reparable pipeline.

For the purpose of this study, transaction histories were extracted for the 120 NSNs, which were recommended by the weapon system item managers, for the period covering October to December 1992. The intransit time was calculated by subtracting the Julian date of the initial supply requisition from the date of carrier delivery at the

depot repair site. An average transit time for each NSN over the three month period was calculated. These resulting averages were used in sampling theory statistics in order to make inferences regarding the reparable intransit population.

Population of Interest

The population of interest for this study was all reparable assets which currently travel through the Air Force logistics pipeline. A representative sample was obtained for the following aircraft without regard to model-type: the F-16, the C-130 and the B-52. Ten stock numbers (NSNs) with the highest frequency of repair were provided to the authors for each of the three aircraft by item managers in each of the System Program Offices for the following weapon subsystem categories: Avionics, Engine Assets, Hydraulics/Pneumatics, and Landing Gear.

Because the assets come from each of the major aircraft subsystems and they represent reparables from three major Air Force weapon systems categories--fighter jet (F-16), cargo and tactical airlift (C-130), and bomber aircraft (B-52)--the sample is fairly representative of the population of reparables within the logistics pipeline.

The bases used in this study were: Moody AFB, Georgia (F-16 source) Little Rock AFB, Arkansas (C-130 source), and Barksdale AFB, Louisiana (B-52 source). Moody, Little Rock and Barksdale AFB are located in the southern region of the country, so variations in flow time which might have

occurred as a result of intransit distance traveled should have been minimized. In addition to serving as sites from which the NSNs were tracked, Moody AFB and Little Rock AFB were also used as sources for conducting on-site and telephone interviews. The interviewing process added continuity to the research and contributed to the validity of the study.

The asset repair facilities which were subjects of the study were Ogden, (OO-ALC), Oklahoma City (OC-ALC), and Warner Robins (WR-ALC). These repair sites were selected because they are responsible for repairing the assets which were recommended by the weapon system item managers. When possible, Line Replaceable Units (LRUs) from different aircraft were tracked to the same depot repair site. For example, the landing gear for all three aircraft were tracked from the three bases to the same depot repair site--Ogden (Figure 5).

Investigative Question #1

The first step in effectively modeling the intransit segment was to answer investigative question one, "What is currently accepted as the standard Air Force description of the intransit segment of the pipeline?". Two primary methods were used to answer this question. First, an extensive literature review was conducted to gather current information regarding the intransit pipeline segment. The review determined the current standard of the intransit pipeline segment. This comprehensive literature review

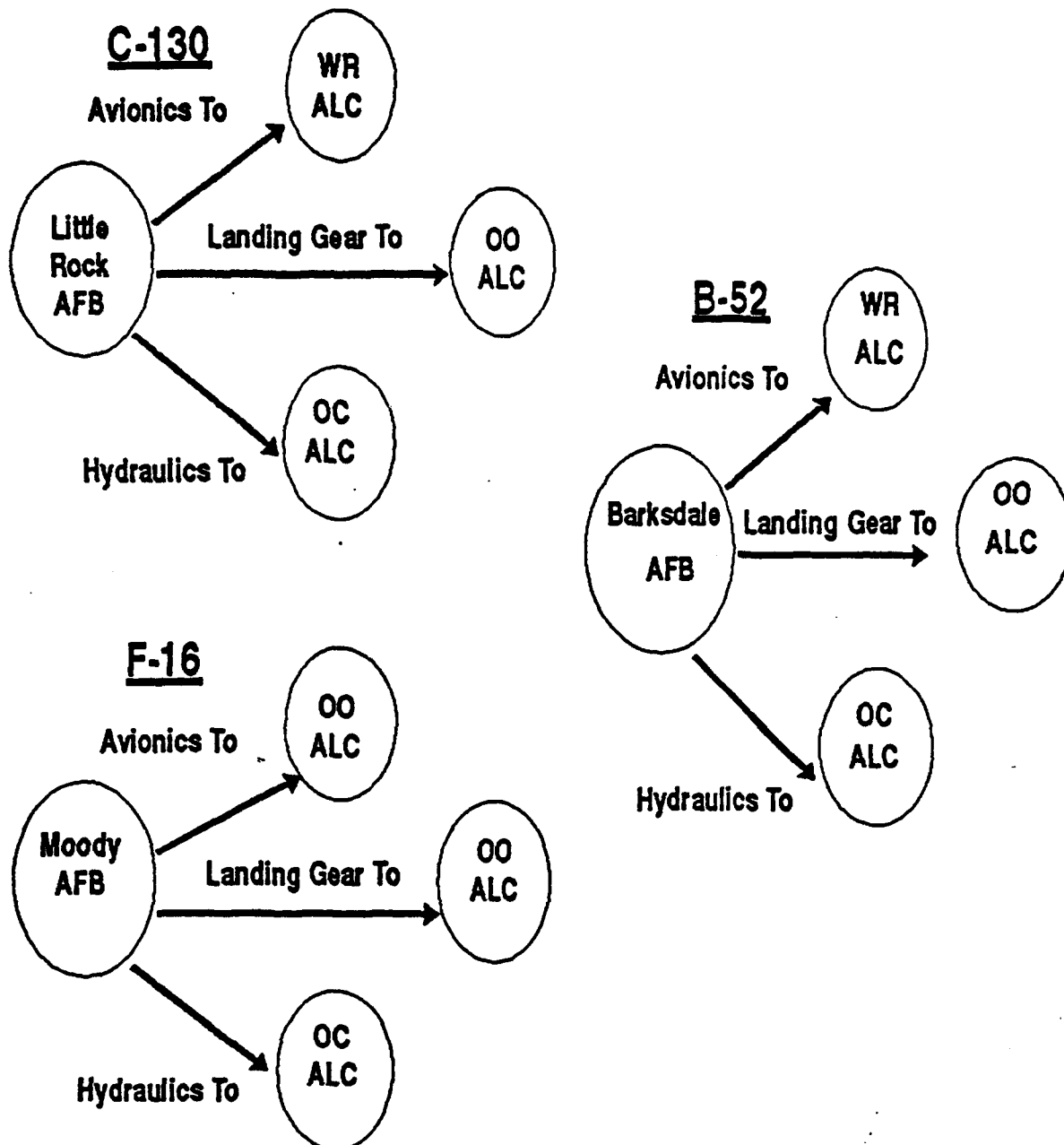
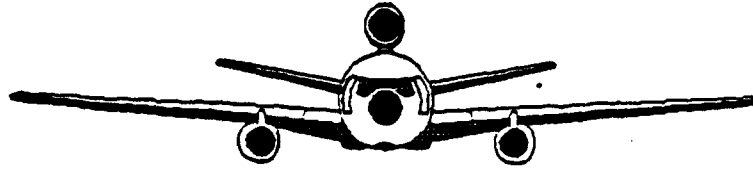


Figure 5. Sample Bases And Associated Depots

validated current conceptual pipeline models as well as identified any unique actions which occur in the intransit segment. This review also provided a concrete definition of the start and stop points for measuring the flow times within the intransit segment.

Second, the study's interview instrument was employed. Transportation personnel at Moody AFB and Little Rock AFB were asked open-ended questions regarding their assessment of the definition of the intransit system. The open-ended nature of the survey encouraged free discussion of issues in the intransit segment and sought to discover "top to bottom" management perspectives regarding this segment's characteristic description. Respondents included transportation commanders and traffic management officers, as well as managers and technicians within the Packing and Crating and Surface Freight sections. The interview instrument also assisted in discovering existing constraints in the intransit system.

Investigative Question #2

"The flow time through the pipeline has a major effect on the amount of inventory required in the pipeline" (23:22). Because of this criticality, the study's second investigative question is concerned with how well retrograde flow times for reparable assets are reflected by intransit pipeline standards. Question two asks: "Do the components of the intransit pipeline represent legitimate reparable asset flow times?" This question was answered by carefully

tracking the sample of 120 reparable NSNs as they flowed through the intransit segments of Moody, Little Rock and Barksdale AFBs until they arrived at depot central receiving. The results of the data collection were compared to the current standards, which were identified by answering investigative question one. This comparison began with small-sample theory statistical analysis and was followed up with a randomized block analysis. If the randomized block design resulted in rejection of the null hypothesis, Bonferroni multiple comparison tests were employed. The Air Force DO41 standard was then compared to the flow time analysis.

Small-Sample Estimation of Population Mean

This study attempted to make accurate estimations regarding the population means for reparable assets in the intransit segment. In order to make such estimates, t-statistics were used to create confidence intervals regarding the mean intransit times for reparable assets in the pipeline (the critical t value was extracted from the table listed in Appendix D). These intervals were interpreted and analyzed based on the current DO41 standard of 16 days. A confidence interval of 99% was established using the following formula:

$$\bar{X} \pm t_{\frac{\alpha}{2}} \left(\frac{s}{\sqrt{n}} \right)$$

where: \bar{X} = the overall intransit flow time mean, s = the standard deviation of the sample, and n = the sample size

(120). The X bar was calculated by summing the averages of all NSN data and dividing by the sample size.

Following the establishment of a confidence interval, a small-sample test of hypothesis was conducted. This test of hypothesis was based on the D041 population mean intransit flow time standard of 16 days. The X bar value used in the confidence interval calculations was used in determining the test statistic value using the formula:

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}}$$

The test hypotheses were:

H . = THERE IS NO DIFFERENCE BETWEEN THE D041 AND THE DATA ANALYSIS.

H . = A SIGNIFICANT DIFFERENCE EXISTS BETWEEN THE D041 STANDARD OF 16 DAYS AND WHAT IS FOUND IN THE STUDY'S DATA ANALYSIS.

This test determined whether data from this study shows sufficient evidence to confirm the accuracy of the D041 standard of 16 days. After the confidence interval determination and the small-sample test of hypotheses were completed, further conclusions were made concerning the nature of intransit flow times by using randomized block tests.

Randomized Block Analysis

According to McClave and Benson, authors of Statistics for Business and Economics, "a randomized block design is one for which treatment assignments are made randomly with

in blocks" (14:887). Observational studies are highly suited to randomized block designs (14:933). As a result, this form of sampling statistics was ideal for this study's data analysis. McClave and Benson provide the following description of the randomized block design:

The randomized block design consists of a two-step procedure:

1. Matched pairs of experimental units, called blocks, are formed, each block consisting of "p" experimental units. Each of "b" blocks should consist of experimental units that are as similar as possible.
2. One experimental unit from each block is randomly assigned to each treatment resulting in a total of $n=bp$ responses (14:896).

The 120 NSNs were the experimental units of the randomized block design and were blocked using the following two designs:

TABLE 4: RANDOMIZED BLOCK #1
TREATMENT

BLOCK	WR-ALC	OO-ALC	OC-ALC
F-16	NSN	NSN	NSN
B-52	NSN	NSN	NSN
C-130	NSN	NSN	NSN

TABLE 5: RANDOMIZED BLOCK #2
TREATMENT

BLOCK	F-16	B-52	C-130
WR-ALC	NSN	NSN	NSN
OO-ALC	NSN	NSN	NSN
OC-ALC	NSN	NSN	NSN

The test hypotheses for the scenarios were:

Scenario #1:

H₀ = THERE IS NO DIFFERENCE BETWEEN ANY OF THE TREATMENTS.

H_a = THERE IS A SIGNIFICANT DIFFERENCE BETWEEN THE MEANS OF AT LEAST TWO OF THE TREATMENTS (i.e., INTRANSIT TIMES FOR WR-ALC, OO-ALC, AND OC-ALC).

Scenario #2:

H₀ = THERE IS NO DIFFERENCE BETWEEN ANY OF THE TREATMENTS.

H_a = THERE IS A SIGNIFICANT DIFFERENCE BETWEEN THE MEANS OF AT LEAST TWO OF THE TREATMENTS (p=F-16, C-130, B-52).

To determine whether or not to accept the study's null hypotheses, the preliminary calculations of MST (Mean Square of the treatments), MSE (Mean Square of the Error), SSB (Sum of Squares of Blocks, SSE (sum of squares of Error), and SS (Sum of Squares, Total) were accomplished. Readers are referred to the McClave and Benson text for details of the formulas used in these calculations (14:890-900).

The values of MST and MSE were used to calculate an F value for the randomized block design. Using an F distribution table and an alpha of .01, a critical "F" test was used to evaluate the study's hypotheses for the aforementioned two scenarios. When the F tests resulted in the rejection of the null hypotheses, comparisons of the various pairs of treatment means were made to determine specifically which pairs differed. These comparisons were important in allowing the authors to determine not only which of the means differed, but also how much they differed. There are various methods for making such

comparisons, which include Sheffe, Tukey, and Bonferroni. This methodology utilized Bonferroni comparisons.

Bonferroni procedures are probably the simplest of all multiple comparison tests. Additionally, because the Bonferroni method is applicable when the family of pairwise comparisons are specified by the user, it was well suited for the analysis of this study (14:873). McClave and Benson state that when using randomized block designs, the Bonferroni method is an effective, yet simple technique of making pairwise comparisons. Furthermore, when the number of blocks is close to or equal to the number of treatments, the Bonferroni method is especially suited to randomized blocks (14:894). Because this study utilizes an identical number of treatments and blocks in both of its randomized block designs, the Bonferroni analysis was an ideal choice.

By completing the randomized block design by determining whether or not to reject the null hypothesis and by completing Bonferroni comparisons on the rejections, a useful analysis and interpretation of intransit flow times were accomplished. This analysis, along with its associated Analysis of Variance (ANOVA) tables, is included in chapter IV.

Investigative Question #3

"Do the measurements used by Air Force Managers properly monitor the components of the intransit segment?" is the study's final investigative question. The sources used to answer this question involved the results of

investigative questions one and two, an examination of relevant Air Force transportation manuals and regulations, and interviews with personnel at the three selected base transportation squadrons.

The answers to the first two investigative questions assisted in answering question three by providing the authors with an accurate description of the current intransit pipeline. This description allowed the researchers to determine how effective currently used measurements provide intransit managers with information to monitor asset movement. Additionally, an in-depth search of USAF transportation manuals and regulations was accomplished to identify any pertinent reports and measurements used by intransit segment managers. These results were evaluated and recommendations were given regarding the effectiveness of the current measurements.

Following the literature search, the interview instrument used in investigative question one was employed to determine: 1) management's definition of the intransit pipeline objective and 2) management's feelings regarding what measurements best assist intransit managers in meeting these objectives.

Findings from the interviews were compared to the results of the literature search. Moreover, the interview results were judged with regard to how well they reflected the intransit description determined in the first two investigative questions. Finally, an overall assessment was

made regarding how well the intransit segment components are being measured.

Effect-Cause-Effect Diagram

The results of the three investigative questions were incorporated into an effect-cause-effect (ECE) diagram. According to Goldratt, effect-cause-effect is a way of proving a system's problems which "rely on the intrinsic logic of the situation" (8:22). By developing an ECE diagram of the intransit segment, the authors were able to show how the various problems of the intransit system are interrelated and to emphasize how these problems impact overall intransit performance. This diagram played a crucial role in conceptualizing the true nature of the intransit pipeline and is included in chapter IV.

Chapter Summary

This chapter described the methods and procedures used in gathering information and collecting data used to answer the study's three investigative questions. After re-stating the thesis's research and investigative questions, a data collection framework was presented. Following a detailed description of the framework, the study's population of interest was discussed. The nucleus of the chapter was a discussion of the specific methods and procedures used to answer each of the study's three investigative questions.

IV. Findings and Analysis

Introduction

As stated in chapter I, the investigative questions provided the specific guidelines for the research and were a means for a detailed analysis of the intransit segment of the Air Force Logistics Reparable Pipeline. This study's investigative questions are:

1. What is currently accepted as the Air Force standard of the intransit segment of the reparable pipeline?
2. Do the standards of the components within the intransit pipeline segment represent legitimate reparable asset flow times?
3. Do the measurements used by Air Force managers properly monitor the components of the intransit segment?

The findings and conclusions discussed in this chapter are presented in order by investigative question.

Investigative Question #1: Air Force Intransit Segment

Standards

Intransit Definitions. For the purpose of this study the authors defined the intransit segment of the reparable pipeline as that portion which involves the movement of a Not Repairable This Station (NRTS) asset from the time it is received by the base Traffic Management Office (TMO) until it arrives at Depot Central Receiving. During the process

of research, the authors found that among those working with the reparable pipeline there are multiple definitions of the intransit segment.

When asked to define the intransit pipeline segment, base level experts working in the TMO organization stated that the intransit segment contained those assets which were actually "in transit" (16). In other words, the segment is comprised of assets which have left base level and are in the process of moving to the depot repair site. Using this description, they define the intransit segment as the process of asset movement between the base and the depot repair sites.

Air Force Regulation 75-1 does not provide a clear definition of the intransit segment; however, all time standards and directives which are listed under the title of "intransit time" involve assets which are moving both to the depot from the base as well as to the base from the depot. Previous theses and other pipeline studies have specified the definition of asset movement from the depot to the base as "Order and Ship Time" (13:123).

Transportation experts at Headquarters Air Force Materiel Command (HQ AFMC), provided yet a different definition of the intransit segment when measuring pipeline time. HQ AFMC Traffic Management (HQ AFMC/LGTT) measures intransit time from the time base supply requisitions a serviceable asset from the depot until the complimentary NRTS asset is actually processed into central receiving at

the depot repair site (18). The Julian date on this requisition is identified by transportation managers as the actual starting point for measuring intransit time. Concerning the ending time, transportation experts refer to the delivery of assets at the depot as "tailgate" time (18).

While this definition is closer to the definition used in previous AFIT theses and the definition used by the authors, it is still significantly different in its description of what actually encompasses the intransit segment. The major difference in this description is the fact that it considers the supply requisition of a serviceable asset from the depot as the first step in the intransit process; however, the observations at both Moody and Little Rock AFBs indicate that the actual intransit pipeline does not begin until after supply turns the NRTS asset over to TMO for processing. Using the HQ AFMC/LGTT definition, the additional time which occurs between the actual supply requisition and the asset's subsequent arrival at the TMO is inaccurately added to intransit asset flow time.

According to AFMC/LGTT, the overall base transportation time for processing reparable assets is considered "passing action" and is not used to compute intransit flow times (18). After in-depth base-level interviews and three days of intransit pipeline observations at Moody AFB, the authors strongly disagree with this assertion. In fact, the base-level processing of NRTS assets thorough the intransit

segment involves processes which are crucial to the overall performance of the logistics pipeline.

For example, without proper identification, inspection, and packaging, NRTS assets would inevitably fail to reach the repair site in proper condition. Additionally, if these assets are not properly scheduled and routed to the depots, the link between the base and its source of repair is ultimately severed. The authors believe that these primary factors, in addition to the myriad of less notable processes involved in the intransit segment, make base-level transportation processing time much more than a mere "passing action".

With the implementation of two-level maintenance, the processes of the intransit segment will become even more crucial. If these operations are monitored as a passing action, especially during wartime scenarios, it could have a disastrous effect on the 2LM concept. Since 2LM will remove the intermediate maintenance which once deployed with the aircraft, the transportation processes of the intransit segment will provide the mandatory connection which moves unserviceable assets to their needed repair facility.

Intransit Components

Research confirmed the fact that there are four basic components in the intransit segment. As identified in Kettner and Wheatley's 1991 thesis, the intransit segment is composed of the following components: 1) Physical preparation 2) Carrier scheduling 3) Cargo loading and 4)

Unserviceable asset movement (13:12). With the exception of the unserviceable asset movement component, these processes all occur at base level under two primary sections--Packing and Crating and Surface Freight.

Physical Preparation. After TMO receives the NRTS asset, the first process is physical preparation, which is the primary responsibility of the Packing and Crating section. Base-level interviews and observations determined that within the TMO, the in-check point for all NRTS assets is the Packing and Crating section. After initial paperwork is accomplished, the NRTS asset, along with its paperwork, is examined for any unique characteristics (determinations involving classified property, hazardous cargo, etc. are made at this point) (16). The asset is then weighed to determine suitable packaging type. Parts 65 pounds or less are typically boxed or mailed by envelope, while items weighing 65 pounds or more are usually crated (17). Once the physical preparation is complete, all pertinent information and paperwork is forwarded to the Surface Freight section for selection and scheduling of a transportation carrier.

Carrier Scheduling. Selecting the mode of transportation is the responsibility of the Surface Freight section. Interviews showed that the primary issues which give the choice of carrier are priority and cost. Because the mode of shipment for TP1 and TP2 assets must have minimal move time, these assets are typically moved via

United Parcel Service (UPS) and Federal Express (16).

Both Moody AFB and Little Rock AFB had specific contracts which required Federal Express and UPS to pick-up assets each day at an established time. TP1 and TP2 assets which could not be moved by Federal Express or UPS due to excessive size or weight, were usually moved by carriers such as Emory Air Freight (16). Although the priority issue is easily met by these carriers, the cost concern is significant. According to carrier schedulers at Moody AFB, quite often the shipment of a single asset by this mode can cost several hundred dollars (17). Typically, assets which are routine are shipped by various surface carriers. Observations at Moody AFB showed that two-level maintenance assets are normally shipped via Federal Express or other express modes. Moody personnel stated that this is primarily due to scrutiny from the CORONET DEUCE two-level maintenance (2LM) study being conducted at Ogden Air Logistics Center (16).

Cargo Loading. The final base-level component involves cargo loading. Once a carrier is selected, cargo is loaded onto appropriate vehicles as they become available. This enterprise can be one of the biggest causes of constraints in cargo flow because of facility capacity and internal operations.

Observations at Moody AFB showed that the availability of equipment can create challenges in the area of cargo loading. One example of a constraint in this portion of the

intransit segment occurred when the lack of a forklift delayed the loading of a commercial carrier by almost an hour. An additional cargo loading constraint concerned manpower. At Moody, personnel in Surface Freight were typically responsible for loading cargo; however, when multiple carriers were simultaneously waiting to be loaded the workload demanded the cooperation of both the Packing and Crating and Surface Freight sections. Thus, without internal cooperation, appropriate equipment, and facilities, significant constraints can arise in the area of cargo loading. As of October 1992, transportation modes no longer include LOGAIR. LOGAIR was a commercial airlift contract typically used for priority shipments. Under the LOGAIR agreement, military personnel were responsible for loading, manifesting and unloading LOGAIR shipments (17).

Because Federal Express, UPS, and other commercial carriers have replaced LOGAIR, base-level transportation experts believe that cargo loading is now a much simpler process (17). Military personnel are no longer required to create a manifest. Instead, Federal Express and UPS drivers create manifests. The manifest can be prepared manually or automatically using a computer and a bar-code scanner (16). With minimal assistance from TMO personnel, the commercial driver loads the assets onto the carrier. Assets are checked against the manifest to ensure transportation control numbers match. After the manifest is signed, base transportation relinquishes property responsibility (16).

In the case of all other surface carriers, the manifest is prepared by surface freight personnel.

Unserviceable Asset Movement. After the NRTS asset is loaded onto an appropriate carrier, the reparable enters what research determined to be the final component of the intransit segment--unserviceable asset movement. Because this process occurs between base processing and depot receipt, the authors consider it to be an external portion of the intransit segment of the logistics pipeline. Because of the transient nature of this component, it poses the most significant challenge in tracking NRTS assets.

Currently, no Air Force system exists for monitoring assets as they travel through the unserviceable asset movement component. However, Federal Express and UPS commercial services offer the capability for maintaining high asset visibility using their computerized bar-code system (16). Base-level customers were highly satisfied with the support provided by these express carriers. With regard to assets shipped by all other modes, base-level experts stated that asset visibility is extremely difficult to maintain because all tracking is based on manually prepared shipping manifests (16).

Asset Movement Standards

As might be expected, given the variations in the intransit definition, there are also differences in the specific time standards allotted for asset movement through this segment. The Recoverable Consumption Item Requirements

System (DO41) assigns a specific average intransit pipeline time equal to 16 days (4:18). This average is computed from actual, estimated and computed values of intransit asset movement. DO41 computations are based on an intransit definition similar to the one used by HQ AFMC/LGTT.

According to HQ AFMC/LGTT, time is calculated from the point when a serviceable asset is requisitioned from base supply until the corresponding NRTS asset is processed into the depot repair facility (18). Because these times are averages, they do not vary between reparable assets. As a result, the DO41 standard is 16 days whether the asset is a high priority asset or whether the reparable is a routine NRTS item returning for depot repair. Additionally, because the standard is the same, all property is processed in relatively the same manner within the intransit segment.

UMMIPS Standard

The objective of the Uniform Materiel Movement and Issue Priority System (UMMIPS) is to provide guidance in satisfying a customer's demand within time standards. UMMIPS uses two basic codes for assigning priorities which indicate the mission essentiality of a unit: the Force/Activity Designator (FAD) and the Urgency of Need Designator (UND). UMMIPS standards are based on supply priorities and deal with the requisitioning of material. The authors discovered that current literature lacks information on the movement of NRTS assets to the depot and no separate priority system exists for NRTS materiel.

AFR 75-1 Standard

AFR 75-1 establishes time standards for the TMO portion of the intransit segment. These standards cover the time between the asset's receipt into TMO until the item is loaded onto the selected carrier. In contrast to the average time used by the DO41, these standards range from 2 to 8 days depending on the Transportation Priority (TP). According to transportation experts commissioned in this study, these priorities are based on the existing supply priority listed on the shipping document which is received with the asset when TMO signs for the item from base supply (16). NRTS assets are not treated differently from other items moving through the TMO. The results of this study's interviews showed that all property which flows through the TMO channels is managed based on two issues: cost and priority. These issues are used regardless of the type of property. Thus, whether an item is a NRTS aircraft part, or a consumable item being shipped to another base for lateral support, the same process of evaluation is used in preparation of transportation.

Any asset which may potentially hinder mission capability (MICAP) or which falls under the TP I category is a priority shipment. These items are moved by priority carriers, usually Federal Express and to a lesser extent United Parcel Service (UPS). Base-level observations revealed that all other property is basically consolidated as routine and is typically sent by commercial surface

carrier. According to Trish Ondo, AFMC/LGTT, this "two-category" priority system fits well into the two-level maintenance (2LM) philosophy (18). In fact, Ms Ondo stated that this two-category system is one of the objectives of 2LM. Under 2LM, a priority is an item which must have minimal time between NRTS turn-in by maintenance and depot repair. These assets must move by express carriers, while all other 2LM assets can be consolidated and moved in a routine manner via commercial carriers.

Investigative Question #2: Intransit Flow Times

Data Retrieval. To answer this question, the authors conducted a data analysis on the 120 National Stock Numbers (NSNs) which composed the study's sample of reparable pipeline assets. The authors encountered major difficulty in obtaining intransit data on these NSNs. Research discovered that no Air Force system effectively tracks reparable assets as they travel from the bases to the depots for repair. After exploring all possibilities, the study's time restriction forced the authors to use two separate sources to retrieve the data for the study's analysis.

First, the Air Force Logistics Information File (AFLIF), which was discussed in chapter III, was utilized. This system was developed during Desert Shield/Storm in order to provide improved asset visibility of assets traveling through the transportation channels of the pipeline. Personnel working at Headquarters Air Force Materiel Command Traffic Management (HQ AFMC/LGTT) stated

that the AFLIF system was effective during the Persian Gulf crisis (18). However, for the purpose of this study, the system was unable to provide total intransit pipeline data.

Despite the efforts of a computer programmer, the AFLIF system could only provide data from the base-level end of the intransit segment. The most representative Not Repairable This Station (NRTS) asset data in the AFLIF system reflected the time of supply requisition of a serviceable asset from the depot. This date is not the exact time base supply delivers a NRTS asset to the TMO, and therefore does not precisely match this study's intransit definition. However, this date was the closest available for measuring the starting point of the intransit segment.

Supply requisition document numbers for the 120 NSNs were extracted from AFLIF. This data covered the first quarter of 1993 and resulted in a total of 810 transactions for the three subject bases. Attempts were made by AFLIF experts to pull tailgate times; however, this information was unavailable. As a result, AFLIF could only provide half of the data needed for the study's analysis.

The authors worked with personnel from HQ AFMC/LGTT in an effort to determine what Air Force system could provide the information needed to determine NRTS tailgate times, and thus furnish the remaining portion of data. After exploring all available options, the only system which contained tailgate data was determined to be the Air Force's D035 system. While this system contained the required data,

extracting the data presented profound limitations. One severe limitation was that the D035 can only retrieve data for transactions which occurred in the last 60 days. Anything beyond the 60-day boundary is archived in the D035 data bank. Obtaining such data requires the assistance of a D035 programmer and additional Air Force funding. Unfortunately, the limited time and funding associated with the study made this option impossible; therefore, the authors were forced to reduce the original data to include only the past 60 days of transactions. Even after reducing the data, the D035 provided limited results. With the 60-day limitation, less than one-third of the original AFLIF data (186 transactions) could be used. Of the 186 transactions input to the D035, only 125 (67%) of the transactions had matching tailgate times.

Analysis of Intransit Asset Flow Times

Mean Intransit Flow Times. Using the restricted data available, the Julian date tailgate times pulled from the D035 were subtracted from the corresponding Julian date of the supply requisitions provided by AFLIF. The 125 transactions which composed the data source for this analysis involved only 34 of the sample's original 120 NSNs. The number of transactions per NSN ranged from a high of 15 for the F-16 main wheel, to a low of one for both the B-52 strut antenna and the F-16 butterfly valve. Sensibly, fewer conclusions can be drawn from the latter stock numbers than those with significantly more transactions.

TABLE 6: NSNs AND ASSOCIATED INTRANSIT AVERAGES IN DAYS

BASE: FB4460, Little Rock

TO:
Warner Robins ALC

	<u>Noun</u>	\bar{X}	
1. 5921-00-570-4365	Sub Assembly Receiver	6	days
2. 5836-01-051-2886	Reproducer Recorder	2	days
3. 5821-01-228-7058	Receiver Transmitter	4	days

TO:
Ogden ALC

	<u>Noun</u>	\bar{X}	
1. 1620-00-896-1203	Main Landing Gear	5.75	days
2. 1620-00-677-6681	Ball Screw	5.67	days
3. 1630-00-908-9999	Dual Control Valve	7	days

TO:
Oklahoma City ALC

	<u>Noun</u>	\bar{X}	
1. 4810-00-706-0266	Butterfly Valve	5	days
2. 1660-00-062-0301	Air Pressure Controller	4	days
3. 6620-00-856-8263	Torquemeter indicator	4.5	days

BASE: FB4830, Moody AFB

TO:
Warner Robins ALC

	<u>Noun</u>	\bar{X}	
1. 5865-01-324-9103	Counter Processor	6	days
2. 5895-01-112-6380	Rec. Transmitter	2.75	days

TO:
Ogden ALC

	<u>Noun</u>	\bar{X}	
1. 6615-01-361-9746	Flt Control Computer	10.25	days
2. 1260-01-251-1150	Electronic Generator	2	days
3. 1270-01-233-0011	Rec. Transmitter	11	days
4. 1270-01-238-3662	Sub Assy. Transmitter	10	days
2. 1270-01-256-6538	Signal Processor	1	days
6. 1270-99-746-8162	Display Unit, HUD	12.22	days
7. 1620-01-136-5173	Control Box	12	days
8. 1630-01-038-9239	Main Wheel	6	days
9. 1620-01-240-4805	Nose Drag Brake	7	days

TO:
Oklahoma City ALC

	<u>Noun</u>	\bar{X}	
1. 1660-01-196-5999	Controller	13	days
2. 1660-01-217-6555	Butterfly Valve	1	days
3. 1660-01-217-6558	Int. Valve	7	days

BASE: FB4608, Barksdale AFB

TO:
Warner Robins ALC

	<u>Noun</u>	\bar{X}	
1. 5985-01-297-2613	Strut Antenna	13.67	days
2. 1280-01-228-7261	Display Generator	4	days
3. 1280-00-186-6298	Trans Modulator	4	days
4. 1280-01-228-3938	Computer Cont Panel	2	days
5. 1280-01-120-7217	Navigation Panel	18.50	days

TABLE 6 (CONTINUED)

TO: Ogden ALC			\bar{X}
	<u>Noun</u>		
1. 1630-01-228-6043	Wheel		10.17 days
2. 1630-00-242-0942	Wheel		9.6 days
3. 1620-00-139-8473	Full-up Landing Gear		10.5 days
TO: Oklahoma City ALC			\bar{X}
	<u>Noun</u>		
1. 1650-00-079-2295	Controller		12.80 days
2. 4320-00-474-3550	Axial Piston Pump		14 days
3. 1660-01-168-9382	Turbine		11 days

The number of flow time days was summed for each NSN and then divided by the number of transactions for that particular NSN in order to calculate the intransit averages. Table 6 itemizes these calculated averages. Looking at the intransit averages in Table 6, it is evident that the average values for the three bases are far below the existing D041 standard. Overall, the averages range from a low of 1 day to a high of 18.5 days.

After talking with experts at base-level, the authors believe that the cause of the 1 day low which was seen for the signal processor moving from Moody to Ogden is due to a priority item or MICAP situation in which the item was sent by express carrier. This minimal value was also seen for the butterfly valve sent from Moody to Oklahoma City. Because this NSN had only one transaction occur during the time period, it is difficult to make assumptions regarding how reflective this value is of intransit pipeline times.

As for the 18.5 day average for the navigation panel which was sent from Barksdale to Warner Robins, the opposite was true. It was shipped as a low priority asset by routine

surface carrier. With regard to lower priority assets, base-level experts suggested that extended intransit time is often due to reconsolidation of carrier loads (17). This can occur when carriers make routine stops along their route, reconsolidating their existing truckloads with other routine pick-ups along the course to the repair site. This process can add days to the intransit process. Because it was discovered that the panel was shipped via routine modes, the authors surmise that the high intransit average is due to the reconsolidation process.

One noticeable factor displayed in Table 6 is the fact that between bases, Little Rock possessed the most consistent intransit averages. The Little Rock averages range from 2 to 7 days with a mean of 4.9 days. The Little Rock consistency is evident for all three depot repair sites and is respectably below the D041 standard of 16 days. In contrast, Moody AFB averages range from 1 to 12.22 days and fail to exhibit the same consistency.

Of particular interest is the wide range of intransit times from Moody to Ogden ALC. Averages range from 1 to 12.22 days. The partial explanation for this range of averages lies in the fact that Moody is a test base in the CORONET DEUCE 2LM study being conducted at Ogden. As observations at Moody AFB demonstrated, avionics items under this program are sent from Moody by Federal Express. Research indicated that both the signal processor which had a 1 day intransit average and the electronic generator which

had a two day average were assets in the 2LM study. Thus, each time these assets were sent to Ogden for repair they were sent via Federal Express, which resulted in minimal flow times to the Ogden repair facility. As for the display unit average of 12.22 days, this asset, although an avionics asset, was not a part of the 2LM study and was never shipped via priority modes (16). Instead, this unit was sent by routine carrier. As mentioned earlier, a probable reason for the extensive time is carrier reconsolidation between Moody AFB and Ogden ALC.

With regard to Moody and the repair site at Oklahoma City, a noticeable figure is the low 1 day average for the F-16 butterfly valve. As previously discussed, this asset had only one transaction recorded in the study's limited research data. Therefore, it is difficult to speculate on the reason for its minimal flow time. The remaining 7 day and 13 day averages to Oklahoma City are more representative of the averages seen throughout Table 6.

Barksdale intransit averages demonstrated relative consistency when examining the Ogden and Oklahoma City repair sites. However, there were significant variances among the flow time averages to Warner Robins. The low average of two days is understandable due to the proximity of Warner Robins to Barksdale AFB. However, while this explanation of proximity effectively justifies the issue of the relatively small two-day average, it complicates the issue surrounding the 18.5 and 13.67 day averages from

Barksdale to the same repair site. Despite research and base-level interviews, no concrete explanation for the significantly large average for the navigation panel was obtained. Most likely, this intransit time is probably due to transportation reconsolidation or excessive amount of time in the Barksdale intransit process. With regard to the strut antenna, because the 13.67 day average involved only one transaction, it is not reasonable to assume that this is either a typical or atypical flow time average for a B-52 strut antenna in the intransit pipeline segment.

Comparisons Among Bases and Repair Sites. In order to make further judgments regarding the intransit process among each of the three bases, a standard deviation was calculated for each base. The standard deviation was then used to determine a 95% and 99% confidence interval for each base. Additionally, small sample tests of hypothesis were conducted to determine whether a significant difference existed between each base and the D041 standard. Table 5 summarizes those calculations. As the researchers expected, Table 7 shows that each of the three tests of hypothesis provided t values which were significantly more than the required reject value of -2.703, thus resulting in a rejection of the null hypothesis for all three bases. A distinctive value in Table 7 is the significant t value of -56.82 calculated for Little Rock. This highlights the fact that while all three bases were below the D041 standard, Little Rock intransit averages were far better than the D041

TABLE 7: SUMMARY OF INTRANSIT AVERAGES

BASE				
VALUE:	LITTLE ROCK	MOODY	BARKSDALE	OVERALL
SAMPLE AVERAGE	6 DAYS	9.39 DAYS	11.13 DAYS	7.25 DAYS
STANDARD DEVIATION	1.04	4.7	4.63	4.02
99% C.I.*	5.52, 6.48	7.69, 11.09	8.54, 13.72	5.40, 9.11
95% C.I.	5.64, 6.36	8.1, 10.68	9.15, 13.11	5.84, 8.66
t VALUE	-56.82	-10.53	-6.96	-13.75
RESULT	REJECT H_0	REJECT H_0	REJECT H_0	REJECT H_0

*C.I.= Confidence Interval

requirement. Accordingly, this simple statistical analysis validated the authors initial theory that the existing D041 standard for intransit flow time is exaggerated. Also, the confidence intervals confirmed existing assumptions held by the authors. Barksdale possessed the highest maximum value. Nonetheless, rounding to the nearest whole number, this maximum value is still two days below the 16-day D041 standard. Confidence intervals for Little Rock and Moody are even farther below this overstated average, with a maximum of 7 days and 11 days, respectively.

Regarding the confidence interval for the overall intransit averages, rounding to the nearest whole number, the authors concluded with 95% confidence that the population intransit flow time is between 6 and 9 days and with 99% confidence that the population intransit flow time

is between 5 and 9 days--both significantly less than the D041 standard of 16 days. The test of hypothesis demonstrated a large difference between the calculated t statistic and the critical t value taken from the critical value t table. The large negative t value of 13.75 underscores the evidence that there is a notable difference between the intransit flow time data collected and the existing D041 standard. As in the original analysis of Table 7, this value, together with the previous confidence interval emphasizes the inflated standard currently used by the D041.

Randomized Block Analysis. After establishing the fact that a disparity existed between the calculated intransit averages and the standard criterion, a randomized block analysis was performed on the study's data. Using the data values in Table 7, intransit flow time averages were calculated for each base and depot repair site. Using these averages, randomized block analysis was performed using two blocking methods. The first design was blocked by aircraft and used the depot repair sites as treatments. A second design blocked on the repair sites and used the three aircraft types as treatments. Table 8 and 9 summarize the values derived for the first randomized block design. Using an F value distribution table, the authors determined an F value of 18. The corresponding F value was tabulated to be $F = 4.39$.

TABLE 8: RANDOMIZED BLOCK #1

BLOCK	WR ALC	OO ALC	OC ALC	BLOCK MEAN
F-16	4.38	8.33	7	6.36
B-52	8.43	10.09	13.4	10.64
C-130	3	6.14	4.5	4.55
TREATMENT MEAN	5.26	8.18	8.3	7.25

*values are in days and represent sample averages for each block.

TABLE 9: ANOVA SUMMARY TABLE FOR RANDOMIZED BLOCK #1

SOURCE	df	SS	MS	F
Treatment	2	17.77	8.89	4.38
Block	2	57.77	28.89	
Error	4	8.1	2.03	
Total	8	83.64		

As a result, the first randomized block design failed to reject the null hypothesis that there were significant differences between treatment means. Thus, while the data analysis showed that there were significant differences between the D041 standard and the sample's intransit averages, the same data failed to prove any differences in intransit times from each of the study's three bases to the associated three depot repair sites. This finding further indicates that the D041 standard is inappropriate, regardless of the depot repair site. The distance traveled from base to repair site does not seem to affect overall intransit averages. Therefore, the interval between bases

and their associated points of repair should not be used to justify the overstated intransit flow time standards.

Tables 10 and 11 summarize the values derived for the second randomized block design.

TABLE 10: RANDOMIZED BLOCK #2

BLOCK	F-16	B-52	C-130	BLOCK MEAN
WR ALC	4.38	8.43	3	5.27
OO ALC	8.33	10.09	6.14	8.19
OC ALC	7	13.40	4.50	8.30
TREATMENT MEAN	6.57	10.64	4.54	7.25

*values are in days and represent sample averages for each block.

TABLE 11: ANOVA SUMMARY TABLE FOR RANDOMIZED BLOCK #2

SOURCE	df	SS	MS	F
Treatment	2	57.87	28.94	14.47
Block	2	17.72	8.86	
Error	4	8	2	
Total	8	83.59		

As in the first block design, the reject region was $F > 18$. The computed F value was determined to be 14.47. Again, because this value is less than the table value of 18 the design failed to reject the null hypothesis. This analysis highlighted the fact that while a difference exists between the D041 standard and the actual intransit averages, there is not sufficient evidence to indicate that there are differences in intransit times among NSNs for the three types of aircraft. Similar to the first block design, which

indicated that distances traveled to the depots do not provide a reason for the inflated D041 standard, the second design indicates a comparable finding regarding aircraft types. The fact that there are no significant differences among aircraft types strongly suggests that even different weapon systems, which are unique to different Major Commands (MAJCOMS), fail to provide a case for the excessive 16-day standard used by the D041.

Summary of Analysis. The analysis for investigative question #2 highlighted the fact that while a difference exists between the D041 standard and the derived intransit averages of the study, because the randomized block designs failed to reject the study's null hypothesis, these differences appeared to be similar across repair sites and aircraft types. Thus, the analysis indicated that the D041 intransit flow time standard is overstated for all NRTS assets in the USAF pipeline, regardless of the base, depot repair site or aircraft type.

Investigative Question #3: Measurements Used by Air Force Managers in the Intransit Segment.

Lack of Intransit Measurements. Based on personal interviews with transportation experts and technicians in the field, it is apparent that not much attention is given to managing asset movements using standardized reports. Moreover, an extensive study of relevant Department of Defense Air Force transportation manuals revealed no mandatory reports or measurements for the intransit segment.

Concerning inventory, Air Force Regulation 75-1 does mandate that a TMO inventory of all on-hand cargo must be completed a minimum of 3 times per week to ensure asset movement (7:47). However, the regulation does not specify the length of time these assets may be held. Furthermore, as seen in Table 1 in Chapter II, AFR 75-1 does provide transportation managers with guidance in monitoring asset movement. Interviews with base level experts, however, show that although the AFR 75-1 standards exist, the actual asset movement philosophy within the Packing and Crating and Surface Freight sections of TMO is basically "management by exception" (16,17).

With very few deviations, when asked what the overall objective of their organization was, TMO personnel replied "to move freight". With this objective in mind, TMO personnel believe that as long as property flows through the system within UMMIPS standards, management by exception serves them well. When a reparable does not move expediently through TMO channels, the asset will receive special attention and become a "problem item". Otherwise, the asset is considered to be routine.

Some optional transportation reports do exist. However, because the management by exception philosophy de-emphasizes the usefulness of these reports, managers in the field do not use them to monitor TMO processing times. In addition, no Air Force system currently exists which allows managers to automatically track transportation times through

the pipeline. Base-level interviews at both Little Rock and Moody AFBS showed that when attempting to measure actual intransit flow times, personnel simply mark the time when a part is turned-in to supply at the receiving base, subtract a fixed amount for supply, and then charge the remaining balance as transportation time (16,17).

According to transportation experts, a possible solution to this problem will be the implementation of the computerized Cargo Movement Operations System (CMOS). The purpose of CMOS is to provide worldwide automated logistics support to base-level transportation activities (18). To accomplish this CMOS will automate the receipt, processing, and movement of material within the pipeline. Experts believe this automation will assist transporters in effectively planning and scheduling shipments into the transportation pipeline.

Intransit Constraints. In order to identify constraints in the intransit pipeline segment, interviews were conducted with transportation personnel at Little Rock AFB and Moody AFB. In addition, an on-site observation was accomplished at Moody AFB. The base-level interviews at Moody and Little Rock AFBs indicated that the most significant system constraint identified by intransit management deals with funding. Carriers such as Federal Express and United Parcel Service (UPS) are used to transport high priority items. Presently, the funds for such services come directly from the budgetary resources of

the base transportation squadron. With current DoD budget reductions, transportation budgets will be significantly reduced; therefore the increased use of priority carriers has further constrained the intransit system process.

Other constraints identified by the interviews include a lack of automation, physical layouts, limitations on equipment and personnel, and the current intransit standard and priority system used for asset flow time. In addition, Moody AFB, which has been a part of the CORONET DEUCE two-level maintenance program, identified constraints which are directly related to the two-level maintenance program. These constraints include the priority requirements for CORONET DEUCE assets. These increases require greater reliance on Federal Express carriers and limit the time available to process such items.

Effect-Cause-Effect Diagram

Theory of Constraint (TOC) principles were applied to the research findings and the intransit system's constraints to develop an effect-cause-effect (ECE) diagram. These constraints represent the causes of poor system performance. The ECE diagram in Figure 6 identifies three core problems which were related to the processes of the intransit segment of the pipeline. The diagram's purpose is to underscore how these various problems are interrelated and emphasize how they impact overall intransit performance. Under the TOC philosophy, performance at the operational level (e.g., base transportation) is assessed by the following measures:

Inventory (I), Throughput (T) and Operating Expense.

According to Goldratt, *inventory* is all the money that a system has invested in the things it intends to sell, *throughput* is the rate at which money is generated into the system through sales, and *operating expense* is all the money that the system spends to turn inventory into throughput (8:10). The intransit segment's three measures of performance--Throughput (T), Inventory (I), and Operating Expense (OE), are typically not used in nonprofit organizations; however, continued budget reductions and dynamic changes in the military establishment make these three performance measures plausible appraisals of the pipeline's effectiveness.

For the purpose of this research, the inventory (I) performance measure is defined as the Air Force investment in the reparable assets which constitute the nucleus of the pipeline. While increases in any type of inventory tend to be detrimental to system performance, increases in work-in-progress inventory are especially degrading to throughput. The increased inventory depicted in Figure 6 is related to such WIP inventory. In the intransit segment of the pipeline, this WIP inventory is synonymous with NRTS assets.

Throughput is defined for this research as the rate at which serviceable assets are generated in the system through the repair process, which ultimately determines weapon systems readiness. The intransit segment is crucial to

overall pipeline throughput. Without the processes of the intransit segment, NRTS assets would be unable to reach the depot for repair, thus drastically affecting the number of serviceable assets being generated into the system. This could have a critical effect on unit mission effectiveness by grounding weapon systems in need of exchangeable component parts. Using the TOC definition of operating expense (OE), this performance measure is defined as the money spent to move reparable assets through the pipeline process in order to maintain maximum levels of mission readiness.

The Intransit ECE. The diagram in Figure 6 was constructed by listing all the UDEs identified in interviews and then clustering those that appeared to be related to each other. "If-then" logic was used to funnel the diagram upward into the three operational performance measures. The diagram is read from bottom to top (the block numbers are listed within each block). Blocks (1), "no system for tracking assets", (9), "DOD budget reductions", and (33) "existing standards/ priorities do not support the goal of pipeline reduction", represent the system's three core problems.

We can follow the logic of the blocks in Figure 6, on the following page, to see an example of how the core problems of the intransit process can ultimately lower pipeline throughput. Starting with the core problem of

budget reductions (block 9), the diagram would be read: "If DOD budget reductions are implemented, then transportation budgets will be reduced (block 10). If transportation budgets are reduced, transporters will be forced to use the most economical mode of transportation (block 11), which will result in the increased use of less expensive routine carriers (block 12). Because routine carriers extend asset transit time (block 13), assets spend too long in the components of the intransit segment (block 7), take too much time to arrive at the depot for repair (block 43), and as a result are not expeditiously repaired (block 44). Thus, assets are unavailable to support the mission (block 45), weapon systems are not mission ready (block 46) and ultimately system throughput is lowered" (block 49). The same method can be used to start at any point in the diagram and flow upward to one of the three performance measures.

Figure 6 highlights this fact by detailing the effect of the three core problems and UDEs on pipeline inventory. The left-hand "chain" flows from the core problem (block 1), "no system to track assets" and accents how the UDEs result in higher inventory. Following the chain, the lack of a tracking system leads to the inability to know where assets are in the intransit system (block 2). Because of this lack of visibility, difficulty arises in effectively measuring legitimate intransit flow times (block 3), which causes difficulty in measuring day-to-day system performance (block

4). Also highlighted in the chain is the existing management philosophy (block 5). Because managers in this segment believe their processes are merely "passing action", they do not think asset tracking in the intransit segment is important; therefore, assets are not tracked (block 6). The eventual result is assets "clogging" the pipeline (block 8), which ultimately leads to increased inventory.

One of the primary causes of increased OE in Figure 6 has to do with increased inventory carrying cost (block 47). This inventory, as mentioned earlier, is typically WIP (which can be defined as NRTS assets), which is attempting to move through the pipeline process in order to reach the depot repair site. Once the NRTS asset has been repaired and is ready to return to base level in a serviceable condition, it becomes throughput. Thus, by maximizing the turnaround rate of NRTS to serviceable assets, there is a beneficial decrease in operating expense, through lowering inventory carrying cost, as well as a beneficial increase in throughput. However, as will be discussed next, the operating expense associated with the transportation aspect of this minimum turnaround time often results in conflict among the three performance measures.

Increased operating expense (OE) can result from the use of priority carriers such as Federal Express. The two UDEs in block 15, "less funding for payroll" and block 18, "less money for material handling equipment (MHE)", each

form chains which highlight the issue of increased operating expense. Starting with block 18, if less money is available for MHE, the MHE availability drops (block 19) and limits the ability to load cargo in a timely manner (block 20). Feeding into this UDE is another chain which arises from the DoD budget reduction constraint (block 9). This chain begins with less funding for personnel pay (block 15), which leads to the elimination of manpower authorizations (block 16) and results in fewer available technicians in the system (block 17). Because fewer technicians are available, the ability to load cargo becomes constrained (block 20). Limitations on cargo loading ability result in excess time spent loading and waiting in the system (block 21). This results in assets spending too much time in the cargo loading subsegment (block 14), as well as spending excess time in various other intransit subsegments (block 7).

Additionally, this cargo limitation (block 20) results in the increased use of priority carriers, such as Federal Express (block 22). Priority carriers are significantly more expensive than routine carriers (block 23), which raises the system's operational measure of operating expense (block 50). Although the use of expensive priority carriers may increase pipeline throughput, it can potentially create a conflict in the goal to decrease operating expenses. A decision must be made regarding the best tradeoff between the cost of using priority carriers and the overall cost

associated with the system's goal of decreasing operational expenses.

A third UDE of the DoD budget reduction problem (block 9) is the requirement to reduce Air Force maintenance costs (block 24). This has led to the implementation of the 2LM program (block 25) which will result in the significant reduction of intermediate base-level repair capability (block 26). This reduction causes a heightened interest in the expedient shipment of NRTS assets to depot repair sites (block 27), and once again leads to the increased requirement for priority carriers (block 22).

In addition, the chain also flows into the UDE which requires the shipment of NRTS assets to the depots for repair (block 27). This requires all assets to pass through the intransit segment (block 28), and have a transportation priority (TP) assigned (block 29). Because these TPs are not respective of asset type (block 30), the result is a lack of NRTS visibility (block 31), which results in NRTS assets being lost in the intransit segment (block 32). At this point, the chain returns to the UDE in block 7.

The authors identified the existing priority and flow time standards (block 33) as another problem currently constraining the effectiveness of the intransit segment. Because existing standards and priorities do not support the system goal of pipeline reduction, priorities are determined without regard to DO41 (block 34) and FAD/UND/UMMIPS

priority based on unit mission (block 38). Failure to consider the D041 in determining priorities (block 34) results in a D041 standard that is not reflective of actual intransit flow times (block 35). Because the D041 standard does not reflect true flow times, the result is an inflated D041 standard (block 36) which is disregarded by intransit managers (block 37). This results in management viewing the intransit segment as a "passing action" (block 5). It should be noted that the "passing action" UDE also arises from the UDEs associated with the "no system to track assets" (block 1) core problem which was discussed earlier.

Because the priority system is based only on unit mission (block 38), overall pipeline time is not a consideration (block 39). The failure to consider overall pipeline time results in the intransit segment being viewed as insignificant (block 40). Thus, supply requisition priorities are concerned with serviceable order and ship time and fail to apply to the shipment of NRTS assets to the depot (block 41). As a result, there is no separate NRTS priority system (block 42), leading to no regard for asset type (block 30) and a lack of NRTS visibility (block 31).

If visibility of NRTS assets diminishes, these assets become lost in the intransit system (block 32), causing increased time in the various intransit subsegments (block 7). The end result is the a "clogged" pipeline (block 8), which leads to increased inventory (block 48). To

illustrate the issues associated with the two chains which branch from the "standards and priorities" core problem in block 33, assume that the priority of a requisition is routine. As a result, even if the associated NRTS asset needs priority in order to minimize its turnaround time, the asset will move on the routine priority which was given to the serviceable requisition. Because routine requisitions slow the turnaround time of NRTS assets, which eventually become the system's measure of throughput, assignment of a routine priority can result in lowered throughput. In addition, this action raises operating expenses because, until the NRTS asset becomes a serviceable asset, this same NRTS asset can be considered base-level WIP, which raises both inventory and carrying cost operating expenses.

ECE Summary. As indicated in Figure 6, the results of the three core problems are higher inventories and operating expense and lower throughput within the intransit pipeline. As the findings of this chapter have shown, the inflated nature of the D041 standard is a major contribution to intransit pipeline system performance. Additionally, the lack of a single effective system for tracking assets through the intransit system has resulted in a lack of asset visibility, a lack of intransit performance measures, and ultimately in excessive WIP inventory and increased operating expense. DoD budget reductions have led the Air Force to implement the 2LM maintenance concept. As the ECE

points out, 2LM's requirement for priority carriers results in greater system throughput; however, at the same time a consideration must be given to the resulting rise in operating expense which is associated with the increased use of priority carriers.

The purpose of the intransit ECE diagram is to demonstrate that the key to improving intransit system performance lies in the exploitation of its three core problems. These problems precipitate the requirement for an effective system of tracking reparables through the intransit segment. They also demonstrate the need for an improved intransit standard and changes in the current reparable asset priority system. The final core problem, budget constraints, poses a major operational challenge. The limited budget must be used in the most efficient manner in order to increase system throughput (i.e. serviceable assets), lower WIP inventory (NRTS assets) and lower pipeline operating expense.

Enhanced Intransit Process Model

The research associated with the literature review and the findings of this chapter, together with the effect-cause-effect diagram, were compiled to create an enhanced model of what the authors discovered to be the processes of the intransit segment of the reparable pipeline (Figure 7a, 7b, 7c). The ECE diagram provided insight into the actual processes within the intransit segment, and thus played a

crucial role in the development of the enhanced intransit process model. This figure embellishes the original model created by Kettner and Wheatley and more accurately describes the intransit segment.

Figure 7a shows that the intransit segment begins when an asset arrives at TMO from the base processing segment. After arriving at TMO, the NRTS asset is inchecked and inspected by Packing and Crating personnel. Contrasting Figure 7a with Figure 3, the enhanced model further details the processes which are annotated in Figure 3 as "TMO prepares to ship asset off-base". The remaining steps in the model in Figure 7a outline the processes which occur in the TMO Packing and Crating section. These processes involve the important steps of matching paperwork, determining packaging type, and properly annotating transportation information onto the NRTS asset paperwork.

After the packing and crating process is completed, the asset paperwork is forwarded to the Surface Freight section (Figure 7b). Surface Freight then determines asset priority based on the paperwork. This evaluation leads to several vital steps in the enhanced model. In comparison, the basic model, which was adapted from Kettner and Wheatley's 1991 thesis, simplifies this vital process into three simple, less specific blocks. The enhanced model in Figure 7b details the multiple steps leading to the determination of

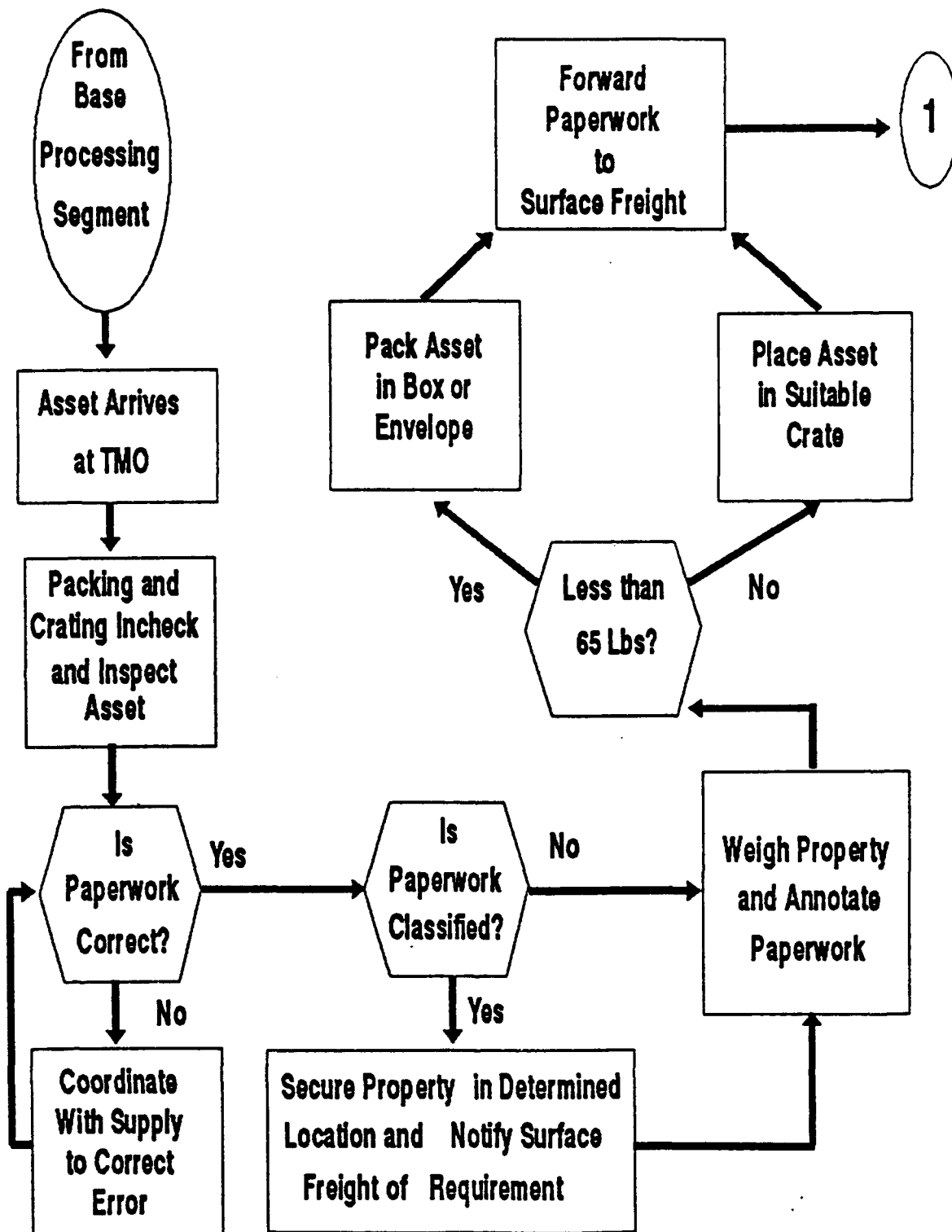


Figure 7a. Enhanced Model of the Intransit Segment

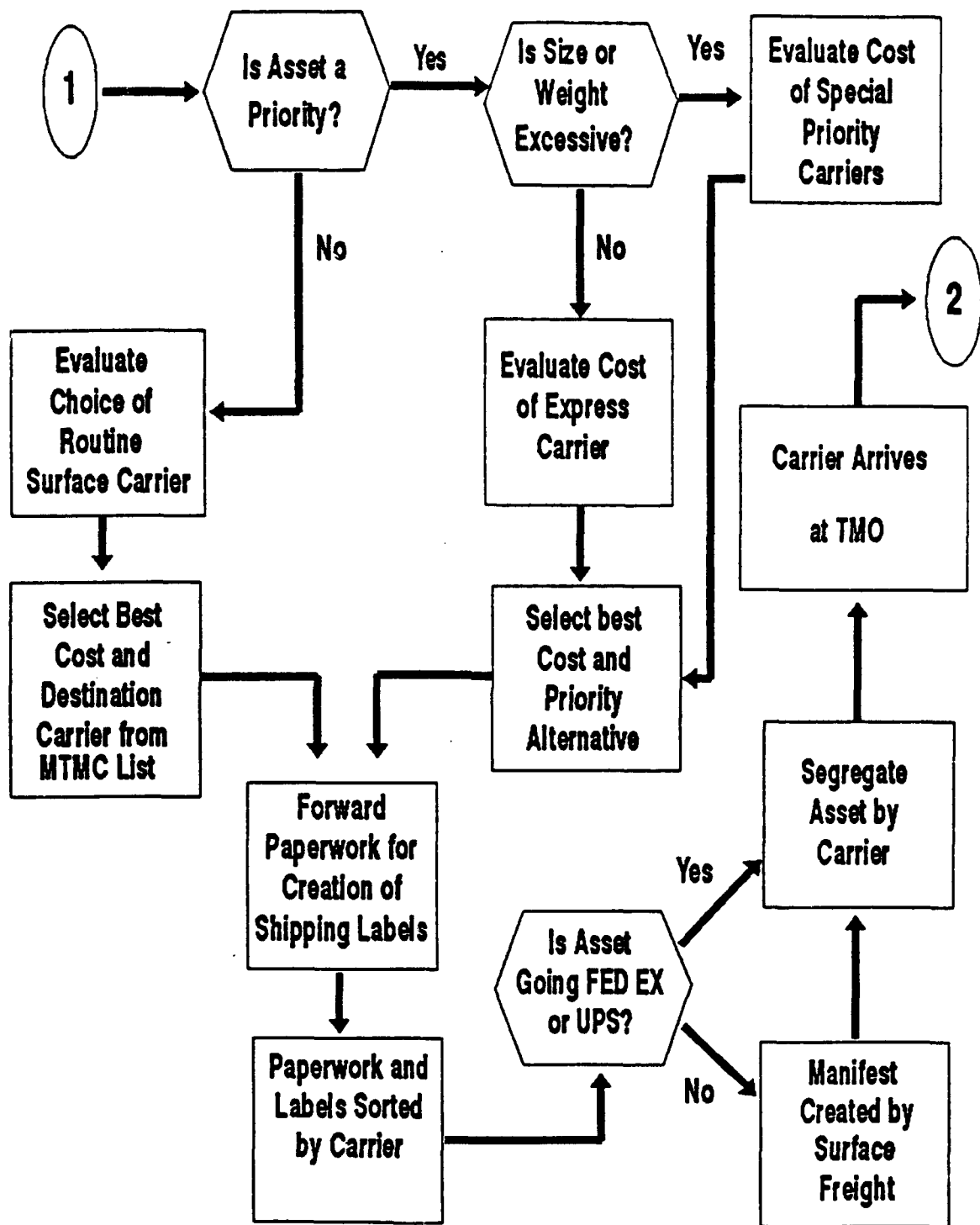


Figure 7b. Enhanced Model of the Intransit Segment

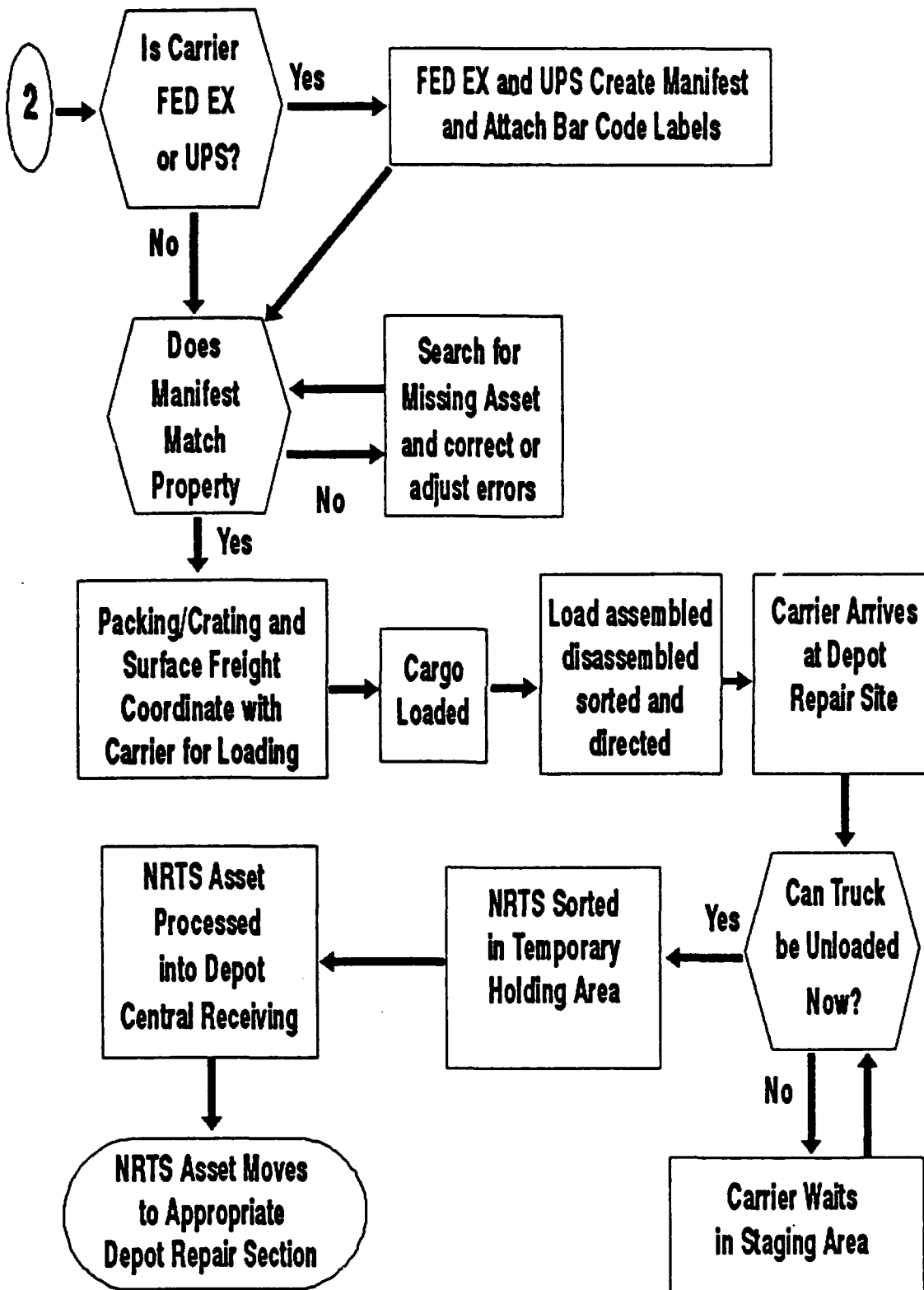


Figure 7c. Enhanced Model of the Intransit Segment

asset priority and carrier selection. First, if the asset is considered routine, surface freight schedules a routine surface carrier to transport the asset. These carriers are selected from the Military Traffic Management Command (MTMC)'s listing of local carriers.

In the case of a priority asset, size and weight must be considered. After an evaluation of priority, size, weight, and cost, Surface Freight selects the most cost-effective priority. Barring any unusual size or weight characteristics, this typically results in the selection of Federal Express or United Parcel Service. Following the selection of a carrier, shipping labels are created and attached to the NRTS asset, along with associated paperwork.

The next steps in the enhanced model involve the creation of the manifest and the arrival of the carrier. If the mode of transportation involves a routine carrier, the manifest is created by Surface Freight personnel. This manifest is matched with the property which is loaded onto the carrier by TMO personnel. As seen in Figure 7c, a slightly different process occurs if the selected carrier involves Federal Express or UPS. In such cases, the manifest is created by the carrier, and a similar process of matching and loading the cargo occurs. Again comparing the enhanced model to the simplified version used by Kettner and Wheatley, the enhanced model describes the loading and transporting of assets in more detail.

After the cargo is loaded, the model process proceeds to the operations which involve the transport of the NRTS asset to the depot for repair. At this point a similarity exists between the two models. As indicated in both the simplified and the enhanced models, actual movement to the depot is identified by the process annotated as "load assembled, disassembled, sorted and directed". This block is a vague portion of the model as well as the tangible intransit process. Because of the transient nature of this component of the intransit segment, it is very difficult to model in intricate detail.

The final step in the enhanced model occurs when the carriers actually arrive at the depot repair site. Figure 7c details the operations which occur upon arrival at the depot. As the model indicates, carriers may or may not be immediately unloaded, and even after assets are unloaded, further intransit time may be expended while waiting in temporary holding areas for inchecking. Once the item has been processed into the depot central receiving section, intransit segment asset flow time ceases and the enhanced model process is completed.

Chapter Summary

This chapter discussed the findings and analysis of the study's three investigative questions. The chapter began with a discussion of the various definitions of the intransit segment. The authors then discussed the

differences which were found to exist in flow time standards. Investigative question two findings were primarily accomplished by performing a statistical analysis of the data gathered on the study's population sample. These findings included a discussion of the problems the authors encountered in obtaining the data used for the statistical analysis. This difficulty occurred due to the lack of an Air Force system for tracking NRTS assets through the intransit segment of the pipeline. The chapter also discussed the lack of management measurements for monitoring the components of the intransit segment.

The chapter concluded with an ECE diagram and an enhanced model of the intransit segment. The purpose of these diagrams was to enhance the former description of the intransit pipeline segment. First, the ECE diagram highlighted the core problems of the system and described how these problems affect system performance, as measured by inventory, throughput, and operating expense. Finally, using the research findings and the ECE diagram, the authors developed an enhanced process model of the intransit segment. The foundation for the model was the simple intransit model described in Kettner and Wheatley's 1991 thesis Figure 3. The enhanced process model embellished and strengthened the original intransit model and more accurately described the processes which comprise the intransit segment of the pipeline.

V. Conclusions and Recommendations

Overview

This chapter draws conclusions about the research findings presented in the previous four chapters, offers recommendations for improving intransit pipeline performance and provides suggestions for further research. The purpose of this research was to develop an enhanced process model of the intransit segment of the United States Air Force reparable pipeline in order to assist Air Force managers in improving the overall performance of the pipeline.

Because previous research had not adequately discussed the role of the intransit segment in the overall pipeline, this thesis analyzed the characteristics of this particular segment by examining the following topics: various intransit components, reparable asset flow times, intransit's role under two-level maintenance (2LM), intransit constraints, and data sources used to manage asset movements within the intransit segment of the pipeline. The conclusions and recommendations resulted from the findings of the literature review discussed in chapter II, the personal interviews and on-site observations conducted by the authors, and the statistical analysis of intransit asset flow time data accomplished in chapter IV. These conclusions and recommendations are addressed in order by investigative question.

Investigative Question # 1: What is currently accepted as the Air Force standard of the intransit segment of the reparable pipeline?

Conclusion #1: There is no single, accepted Air Force archetype of the intransit pipeline. Definitions given by transportation experts vary, depending on whether they are located at a base, a depot or at Headquarters Air Force Materiel Command. In concert with this issue, the time standards for moving NRTS assets from the base to the depot for repair also vary among Air Force Regulation 75-1, UMMIPS, and the DO41 criterion.

Moreover, these standards are used for regulating both serviceable asset shipments to the bases as well as NRTS shipments to the depots. Thus, there are profound disparities which exist within the Air Force concerning the exact standard of the intransit segment. The authors believe that a clear and unified definition of this segment is essential for significant process improvement within the intransit segment, as well as the overall pipeline.

Conclusion #2: The steps in intransit segment asset movement overlap each other and actually occur concurrently. Previous studies identified asset movement as being a sequential series of preparations which occurred within four primary intransit components. However, after the study's interviews and observations, the authors concluded that these preparations are in fact concurrent operations. In

addition, the authors also ascertained from interviews that these concurrent operations receive little attention within the Air Force and are not viewed as a significant part of the logistics pipeline. In fact, the view among personnel at base level is that their segment has little effect on the overall pipeline process.

Recommendation #1: A single definition of the intransit segment should be established and sanctioned at all Air Force levels. The authors believe that unless a single Air Force definition of the intransit segment is accepted, this portion could become the "weak link" in the chain of the Air Force logistics pipeline. Following this postulation, it should be the goal of the Air Force logistics community to adapt a single effective intransit description. In light of the implementation of 2LM, which requires the efficient turnaround of NRTS assets, the need for a concise definition is crucial.

Additionally, a concerted effort must be undertaken to educate personnel at all Air Force levels on the intransit segment's impact on the overall effectiveness of the pipeline. This is especially true at base-level, where individuals are unaware of the importance of their segment and how it relates to the entire pipeline process.

Recommendation #2: Separate time standards should be created for NRTS assets. With the implementation of 2LM, the turnaround time between a NRTS asset shipment and its

associated repair will be a critical aspect of the pipeline. Under the current transportation system, a designated "intransit standard" for NRTS assets does not exist. Instead, NRTS standards are merely a reflection of order and ship time standards.

Using previous definitions of the various Air Force logistics pipeline segments, the authors suggest creating two distinct standards within the transportation channels of the pipeline. First, there should be an order and ship time standard, which would cover serviceable assets being shipped from the depot to the base. Second, an intransit standard should be imposed which would cover NRTS asset flow times to the depot repair sites. Developing a separate NRTS flow time standard would place needed emphasis on the intransit time for such assets.

This added emphasis should improve the turnaround time for all reparable in the pipeline. As a result of the intransit flow time analysis in chapter IV, the authors also suggest that these standards should be significantly less than the current 16 day D041 standard. Based on intransit average flow times, the authors recommend lowering the D041 standard to 9 days. According to an Air Force Logistics Management Center study of reparable intransit times, a potential savings of \$25 million per day could be realized by a one day reduction in overall pipeline time (20:19). As

a result, lowering the intransit CONUS standard to 9 days could translate into savings of \$175 million.

Investigative Question #2: Do the standards of the components within the intransit segment represent legitimate reparable asset flow times?

Due to the lack of a single Air Force system for tracking asset flow times through the intransit segment, this question was the most challenging aspect of the study to research. As discussed in Chapter IV, the authors had no other option but to use a makeshift method of extracting the required data. Consequently, the authors infer that it is almost impossible to establish an effective standard without legitimate data upon which to base the standards.

Conclusion #1: Existing standards do not legitimately reflect actual intransit flow times. From the research conducted, it appears that current standards are merely arbitrary estimations. Moreover, statistical data analysis indicated that the maximum intransit flow time was approximately 9 days, thus illustrating the inflated nature of the DO41 standard of 16 days. This inflated nature leads to management disregard for the standard, therefore failing to contribute to process improvements in the intransit segment. In addition, the analysis showed that there were no significant flow time differences between aircraft types or repair sites. Consequently, while intransit flow times

are inflated, they do not differ according to aircraft type or repair location.

Recommendation #1: The Air Force should implement a single system for tracking reparable assets through the intransit segment of the pipeline. Transportation experts believe that the Cargo Movement Operations System (CMOS) would satisfy this requirement. However, this system was developed prior to December 1989 and has yet to be implemented. This system has been designed to automate the process of in-checking assets into the Traffic Management Office and effectively monitor assets as they flow through the various components of the intransit segment until they arrive at depot central receiving.

The authors recommend that the Air Force emphasize the expedient activation of CMOS. By implementing this system, Air Force managers will be able to extract representative asset flow time data, thereby assisting experts in the development of legitimate flow time standards for the intransit segment.

Recommendation #2: Separate intransit time standards should be developed for CONUS and overseas bases. In order for flow times to be as relevant as possible, it is only logical that the intransit standards for assets moving from overseas bases to stateside repair sites should be greater than comparable standards for assets moving through CONUS to CONUS intransit channels.

Investigative Question #3: Do the measurements used by Air Force managers properly monitor the components of the intransit segment?

The authors ascertained that very few measurements are used to monitor the components of the intransit segment. Research revealed that no attention is given to managing asset movements at base level using standardized reports, while minimal attention is given to such reports at the Major Command (MAJCOM) level. As previously discussed, the Air Force places little relevancy on the intransit segment; consequently, there are no measurements used by Air Force managers to monitor the movement of reparable assets. Also, to obtain a clearer picture of the processes which occur among the various components of the intransit segment, the authors constructed an ECE diagram (Figure 6) which identified the effect of three core problems on intransit pipeline performance.

Conclusion #1: Operational measurements are not used at base-level for monitoring the components of the intransit segment. Because little or no relevancy is placed on the intransit segment, transportation experts have no reason to use reports to monitor the performance of base-level operations. With no requirement from MAJCOMs to use operational measurements, transporters will continue to employ their proven "management by exception" philosophy, which simply calls for a reaction to a situation after it

becomes a serious problem. The authors believe that this philosophy is inefficient and can pose serious problems to operational effectiveness.

Conclusion #2: Currently, no MAJCOM attention is given to the actual time required to move NRTS assets through the intransit segment of the pipeline. MAJCOM transportation managers consider the intransit segment's role in the pipeline to be insignificant. Intransit time is simply measured as the time from when a supply NRTS asset requisition is initiated until the time that asset arrives at the depot repair site. Moreover, no system exists for tracking the time assets move through the various intransit subsegments.

Conclusion #3: The ECE diagram demonstrates the need for an improved intransit standard for NRTS assets, as well as the requirement for an effective system for tracking reparable through the intransit segment. The authors concluded that there are three core problems within the intransit segment. These three problems are: lack of an asset tracking system, an ineffective standard and priority system, and DoD budget reductions. As can be ascertained from the ECE diagram, the repercussions of these core problems on operational effectiveness measures are lower throughput (slow turnaround of NRTS assets), higher work-in-process inventory (NRTS assets), and higher operating expense. Improved intransit system performance lies in the

exploitation of these core problems. Optimizing these core problems requires an effective system for tracking reparable assets, as well as an individual NRTS priority system.

Recommendation #1: Transportation managers should implement measurements for each of the major sections of the Transportation Management Office (TMO). After CMOS is implemented, base-level transportation managers will be provided with the necessary measurement capability to monitor asset movement through the entire intransit segment. The authors recommend that base managers use this capability to track assets as they travel through each of the major portions of the enhanced model (Figure 7). Managers should separately measure the time required assets spend in the Packing and Crating, Surface Freight, Cargo Loading, and Asset Movement functions. By segregating the functions, managers will be able to more effectively identify system constraints.

Recommendation #2: At MAJCOM levels more emphasis should be placed on using strategic reporting measurements in establishing standards which more accurately reflect intransit pipeline processes. The authors believe that such attention is necessary at MAJCOM levels where pipeline standards, such as the D041 criterion, are set. As mentioned earlier, upper management places little significance on this portion of the pipeline. In order to convince base transportation experts that their segment of

the pipeline is as critical as any other segment, MAJCOM experts must consider intransit time important enough to track by using formalized measurements. If CMOS is implemented, this system will provide transportation managers at all Air Force levels with the necessary measurement capability to regulate asset movement. CMOS will not only give base-level managers the measurement tools required for managing base-level intransit components, but will also provide MAJCOMs with the inputs for developing accurate flow time standards.

Recommendation #3: **Transportation managers should use ECE diagrams to determine weak links in intransit system performance.** The authors' ECE diagram demonstrates that by graphically depicting core problems and their relationship to pipeline performance, an effective management tool can be utilized to improve system performance. The diagram indicates that a significant intransit issue concerns budget constraints. As the entire defense community is keenly aware, the shrinking Department of Defense budget must be managed as efficiently as possible. The authors recommend that management utilize tools such as ECE diagrams in order to concentrate on remedying the system's core problems. By concentrating on these constraints, managers can focus on eliminating the root of the problem, rather than simply addressing the symptoms associated with ineffective pipeline performance.

Suggestions for Further Study

During the course of this research, the authors discovered that no system of automation existed within the intransit segment of the pipeline. From interviews with TMO experts, it was determined that CMOS should solve the lack of intransit automation. Consequently, once CMOS has been fully implemented, research should be conducted at a test base to determine the effectiveness of the system in tracking asset movements through pipeline transportation channels.

Because the TMO at Moody AFB was one of the principal sources for this research, the authors recommend that it serve as a test site in order to compare performance results before and after CMOS implementation. The authors recommend that the research begin with an extensive base-level investigation to determine how TMO personnel are benefiting from the CMOS system. This research should determine whether or not CMOS has improved overall processes in the intransit portion of the pipeline. In addition to this study, research should be conducted to evaluate the authors' suggestion of implementing separate tracking measures for assets moving through the various TMO functions.

Because CMOS proposes to enhance the capability of obtaining intransit flow time data, it is also recommended that an intransit analysis be conducted to compare intransit times for both stateside and overseas shipments. CMOS

should provide researchers with more substantial amounts of data than the authors of this study were afforded. Using the data from CMOS, the authors recommend that researchers employ a similar methodology to the one used in this study. By using a similar research technique, conclusions can be drawn regarding the validity of the current study in determining the inflated nature of current intransit flow time standards. This research should enhance the current study and further improve the ability of the Air Force to establish more accurate standards for the intransit segment.

Summary

This thesis was a detailed examination of the intransit segment of the Air Force logistics reparable pipeline. The study utilized a thorough literature review, personal interviews, a statistical analysis of intransit flow times, and an effect-cause-effect diagram to develop an enhanced process model of the intransit segment. This model accurately reflects the functions within the intransit segment and expands on previous efforts to describe the processes of this segment. Thus, this research provided an in-depth look at a segment of the logistics pipeline that had been virtually unresearched.

As a result of this study, the authors have determined that intransit segment processes play an important role in the overall pipeline and should be considered more than just "passing action". This conclusion is even more relevant in

light of recent budget reductions, the elimination of LOGAIR, and most importantly the implementation of the 2LM concept, which will heighten the criticality of the intransit segment in the overall pipeline process.

Before 2LM, intermediate maintenance diminished the need for minimal asset movement through the pipeline. However, since the implementation of 2LM, the importance of the intransit segment of the pipeline has increased. The intransit segment now provides a crucial "link" in the pipeline "chain" and connects base-level mission needs with depot repair sites. The expedient movement of NRTS assets through the intransit segment will greatly contribute to the ultimate success of the 2LM concept. It is the expressed hope of the authors that this study will educate Air Force managers at all levels on the importance of the intransit segment. Without a doubt, the impact of this segment will be vital in the quest to continue improving the processes of the overall Air Force reparable pipeline.

Appendix A: Glossary of Acronyms

AFIT	Air Force Institute of Technology
AFLIF.	Air Force Logistics Information File
AFMC	Air Force Materiel Command
AFMC/LGTT.	Air Force Materiel Command Traffic Management
AFLMC.	Air Force Logistics Management Center
AFR	Air Force Regulation
ANOVA.	Analysis of Variance
CMOS	Cargo Movement Operations System
CONUS.	Continental United States
DoD.	Department of Defense
D041	Recoverable Consumption Item Requirements System
ECE	Effect-Cause-Effect
FAD	Force/Activity Designator
Ha	Test Hypothesis
Ho	Null Hypothesis
LRU	Line Replacement Unit
MSE	Mean Square of Errors
MST	Mean Square of Treatments
MTMC	Military Traffic Management Command
NRTS	Not Repairable this Station
NSN	National Stock Number
OC-ALC	Oklahoma City Air Logistics Center
OO-ALC	Ogden Air Logistics Center
RDD	Required Delivery Date
SDD	Standard Delivery Date
SRU	Shop Replacement Unit
SSB.	Sum of Squares of Blocks
SSE.	Sum of Squares of Errors
SST.	Sum of Squares Treatments
TCN.	Transportation Control Number
TOC.	Theory of Constraints

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Appendix B: Base-Level On-Site Interview Instrument

1. In general terms, explain what happens to a reparable asset from the time it is received from supply until transportation relinquishes responsibility.
2. The process I just asked you to explain has been identified as being a significant portion of what is termed the "intransit segment" of the Air Force Logistics Pipeline. In your own words, what do you see as the objective of this portion of the pipeline?
3. Explain the priority system used by the TMO for processing and shipping reparable.
4. How are assets tracked from the as they flow from the supply/transportation interface to until they are loaded onto the eventual carrier?
5. What procedures are used in determining the mode of shipment for a reparable asset?
6. Can reparable assets be tracked from the time they are picked up by the carrier until they are received at the depot? If so, how?
7. What are your asset flow time standards?
8. What are these standards based on?
9. How effective is your organization in meeting these standards?
10. What performance measurements are used in your organization regarding reparable assets?
11. What management reports and information do you use to administer personnel and processes within your organization?
12. What specific factors act as constraints in your organization? What is being done to remedy them?
13. If you could eliminate one particular constraint, what would it be?
14. How has implementation of the Two-Level Maintenance program affected transportation operations?

Appendix C: Study's Initial Reparable Asset Sample

C-130 NSNs

C-130 Avionics Assets

Noun

1.	5921-00-570-4365	Sub-Assembly Receiver
2.	5836-01-051-2886	Reproducer Recorder
3.	5821-01-228-7058	Receiver Transmitter
4.	5821-01-093-9852	Video Sensor Head
5.	5821-01-163-4456	Circuit Card Assembly
6.	5826-00-557-5818	Course Indicator
7.	5895-00-117-4118	Receiver Assembly
8.	5895-00-823-2912	Power Cable Assembly
9.	5895-01-112-6380	Receiver Transmitter
10.	5895-01-151-5848	Antenna Coupler

C-130 Landing Gear Assets

1.	1620-00-896-1203	Main Landing Gear
2.	1620-00-677-6681	Ball Screw
3.	1630-00-908-9999	Dual Control Valve
4.	1620-01-263-6733	Ball Screw
5.	1620-01-168-2419	Ball Screw
6.	1620-01-065-4867	Ball Screw
7.	1620-00-365-4001	Ball Screw
8.	1630-00-825-4794	Multi-Disc Brake
9.	1630-01-038-5126	Main Landing Wheel
10.	1630-00-914-1329	Nose Landing Wheel

C-130 Hydraulics Assets

1.	4810-00-706-0266	Butterfly Valve
2.	1660-00-062-0301	Air Pressure Controller
3.	6620-00-856-8263	Torquemeter indicator
4.	2935-01-202-5339	Lubricating Cooler
5.	6615-00-315-5862	Cage Assembly
6.	1650-00-872-7516	Constant Speed Drive
7.	1660-00-195-2729	Oxygen Regulator
8.	6615-00-707-6478	Rate Gyroscope
9.	6610-00-821-2635	Altitude Indicator
10.	6620-01-172-6946	Torquemeter Indicator

C-130 Engine Assets

1.	2840-00-109-6465	Turbine
2.	2840-00-010-4046	Torquemeter Assembly
3.	2840-00-009-7603	Turbine Cage
4.	2840-00-893-1321	Turbine Bearing

Appendix C: Study's Initial Reparable Asset Sample

C-130 Engine Assets

	<u>Noun</u>
5. 2840-00-491-5767	Inlet Casing
6. 2840-00-110-8666	Seal Assembly
7. 2840-00-014-1748	Tie Bolt
8. 2840-01-059-1355	Turbine Rotor
9. 2840-01-061-5078	Compressor Assembly
10. 2840-00-225-0953	Turbine Inlet

F-16 NSNs

F-16 Avionics Assets

1. 5865-01-324-9103	Counter Processor
2. 5895-01-112-6380	Receiver Transmitter
3. 6615-01-361-9746	Flight Control Computer
4. 1260-01-251-1150	Electronic Generator
5. 1270-01-233-0011	Receiver Transmitter
6. 1270-01-238-3662	Sub-Assembly Transmitter
7. 1270-01-256-6538	Signal Processor
8. 1270-99-746-8162	Heads Up Display Unit
9. 5998-01-212-2950	Antenna
10. 6605-01-256-2380	Navigational Unit

F-16 Landing Gear Assets

1. 1620-01-136-5173	Control Box
2. 1630-01-038-9239	Main Wheel
3. 1620-01-240-4805	Nose Drag Brake
4. 1630-01-217-3141	Wheel Speed Sensor
5. 1630-00-852-1432	Nose Wheel
6. 1630-01-298-6838	Brake
7. 1620-01-296-3911	Main Strut
8. 1620-01-162-7518	Nose Strut
9. 1620-01-071-0535	Axle
10. 1620-01-234-8655	Main Drag Brake

F-16 Hydraulics Assets

1. 1660-01-196-5999	Controller
2. 1660-01-217-6555	Butterfly Valve
3. 1660-01-217-6558	Intake Valve
4. 1660-01-363-2742	Turbine
5. 1660-01-345-2115	Valve
6. 1660-01-052-5357	Controller
7. 1660-01-107-2459	Turbine
8. 1660-01-134-3021	Controller
9. 1660-01-134-3020	Valve
10. 1660-01-251-2549	Controller

Appendix C: Study's Initial Reparable Asset Sample

F-16 Engine Assets

	<u>Noun</u>
1. 5340-01-056-2695	Bracket
2. 3040-00-365-0248	Connecting Link
3. 4810-01-035-0234	Anti-ice Valve
4. 6685-01-061-0362	PT6 Probe
5. 3040-01-267-7735	RCVV Left Arm Assembly
6. 2995-00-371-5916	RCVV Cover Assembly
7. 2840-01-013-5155	Front Fan Duct
8. 2840-01-308-0046	Rear Fan Duct
9. 2840-01-179-5109	Pressure Tube

B-52 NSNs

B-52 Avionics Assets

1. 5985-01-297-2613	Strut Antenna
2. 1280-01-228-7261	Display Generator
3. 1280-00-186-6298	Trans Modulator
4. 1280-01-228-3938	Computer Cont Panel
5. 1280-01-120-7217	Navigation Panel
6. 5821-00-371-4346	STV Camera
7. 1280-00-159-6188	FLIR Scanner
8. 5821-00-186-6309	TV Monitor
9. 1280-00-159-6185	Servo Control Unit
10. 1280-00-250-1236	Video Distribution Unit

B-52 Landing Gear Assets

1. 1630-01-228-6043	Wheel
2. 1630-00-242-0942	Wheel
3. 1620-00-139-8473	Full-up Landing Gear
4. 1610-00-900-9739	Wheel
5. 1620-00-139-8478	AFT Landing Gear
6. 1620-00-025-4773	Drag Strut
7. 1620-00-216-0993	Left Swivel
8. 1620-00-216-0994	Right Swivel
9. 1620-00-567-6803	Steering Valve
10. 1650-00-219-3602	Bungee/LE MAC Code

B-52 Hydraulics Assets

1. 1650-00-079-2295	Drive, Constant
2. 4320-00-474-3550	Axial Piston Pump
3. 1660-01-168-9382	Turbine
4. 2995-01-254-3109	Engine Starter
5. 4810-00-529-1029	Gate Valve
6. 4810-00-650-1235	Linear Valve
7. 1660-00-473-4256	Temperature Sensor

Appendix C: Study's Initial Reparable Asset Sample

B-52 Hydraulics Assets

		<u>Noun</u>
8.	1650-00-456-8609	Cylinder Assembly
9.	1650-00-888-9825	Reservoir
10.	1660-00-625-3033	Regulator

B-52 Engine Assets

1.	2840-01-167-9584	Axial Compressor Case
2.	2840-01-167-9586	Exhaust Turbine Cone
3.	2840-01-167-9604	Gas Turbine Case
4.	2840-01-167-9589	Gearbox Housing
5.	2840-01-167-9602	Turbine Bladeset
6.	2840-01-168-0342	Turbine Heat Shield
7.	2840-01-169-2252	Turbine Case
8.	2840-01-167-9523	Seal Assembly
9.	2840-01-167-9585	Inlet Casing
10.	2840-01-167-9587	Turbine Casing

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Vita

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